# WATER QUALITY IN EVAPORATION BASINS USED FOR THE DISPOSAL OF AGRICULTURAL SUBSURFACE DRAINAGE WATER IN THE SAN JOAQUIN VALLEY, CALIFORNIA

# 1988 AND 1989

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

3443 Routier Road, Suite A
Sacramento, CA 95827-3098

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**CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD**

**CENTRAL VALLEY REGION**



The Staff Involved in the
Preparation of This Report Are:

**Jeanne E. Chilcott, Associate Land and Water Use Analyst**
**Dennis W. Westcot, Senior Land and Water Use Analyst**
**Anthony L. Toto, Water Resource Control Engineer**
**Cassandra A. Enos, Assistant Water Resources Specialist**

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## EXECUTIVE SUMMARY

During June 1988 and June 1989, Regional Board staff conducted water and sediment quality surveys of agricultural evaporation basins in the Tulare Lake Basin. The surveyed facilities are used to store and evaporate agricultural subsurface drainage water.

The mineral quality, as well as the trace element concentrations for water from the various inlets and basins, varied widely. Trace elements with excessively high relative inflow concentrations as compared to a background of seawater included: selenium, boron, arsenic, molybdenum, uranium, and vanadium. The same elements appeared to be at elevated concentrations in the ponded water when compared to natural saline lakes.

During 1988 and 1989, total dissolved solids (TDS) concentrations in the inflow water were approximately the same as the 1986 and 1987 range of 1,200 to 51,350 mg/L. The water being discharged into the basins was predominately a sodium sulfate or sodium sulfate-chloride type water.

A number of trace element concentrations in the inflow water do not appear to have changed since 1985. Selenium, molybdenum, and boron concentrations have all remained fairly constant over time with geometric means of 7 $\mu$g/L, 550 $\mu$g/L, and 9 mg/L, respectively, for the 1988 and 1989 surveys.

Arsenic and vanadium are the only trace elements that appeared to have increasing inlet concentrations. Geometric means were 38 $\mu$g/L and 54 $\mu$g/L for arsenic and vanadium, respectively. The increasing concentration trend will continue to be monitored.

The concentrations of constituents in the ponded waters of the basins varied widely. Selenium and boron concentrations remained fairly consistent between 1985 and 1989 with geometric means of 16 $\mu$g/L and 27 mg/L, respectively during the 1988 and 1989 surveys. Arsenic and molybdenum concentrations, however, appeared to be increasing between 1985 and 1989. Only overall vanadium concentrations were lower in the ponded basin water than in the inflow. Basin concentrations had a geometric mean of 27 $\mu$g/L while the inlet geometric mean was 54 $\mu$g/L.

As was noted in previous reports (Westcot et al, 1988 a and b), geologic setting continues to influence trace element concentrations in both the inflow to and ponded water within the basins. Selenium and boron continue to be found at the highest concentrations in alluvial fan settings while arsenic, molybdenum, and vanadium have their highest concentrations in lake bed settings.

Elevated uranium concentrations were first detected in 1988 during a screening of water samples for trace elements. During 1989, uranium was again analyzed. For the inlets, the 1989 maximum concentration (3,100 $\mu$g/L) was considerably higher than the 1985 to 1988 maximum (1,200 $\mu$g/L); however, the geometric mean (190 $\mu$g/L) remained relatively stable (175 $\mu$g/L for 1985 to 1988).

The extremely high total recoverable uranium concentrations found in the evaporation basins indicated the possibility of elevated uranium by-products, such as radium 226 (Ra 226). Radium, which has geochemical properties similar to those of barium, is especially hazardous because of its easy incorporation in bone, leading to malignancies (Schroeder et al., 1988).

During 1989, 71 of the water samples containing the highest reported uranium concentrations were analyzed for Ra 226. Reported Ra 226 concentrations ranged from 0.1 to 3.1 picocuries per liter (pCi/C). One curie equals a unit of activity which in turn equals 2.22 X $10^{12}$ decays per minute. Although no standards are available for aquatic life, the Federal and State Drinking Water Standards for radium are 5 pCi/L. No radium concentrations detected in the agricultural basins exceeded the standard.

Levinson and Coetzee (1978) determined that if a system is in equilibrium, a rough guideline for Ra 226 would be 0.7 pCi/L radium per part per billion uranium. Using that assumption, based on reported uranium concentrations ranging from 330 to 22,800 ppb, Ra 226 should range from 230 to 15,600 pCi/L in the evaporation basins of the Tulare Lake Basin. The extremely low radium values indicate a case of gross disequilibrium. During their study, Levinson and Coetzee (1978) also determined that ground water transported uranium can be significantly out of equilibrium if it is less than one million years old due to radium's limited mobility. Also, carbonates and sulfates of uranium have very low solubilities. The evaporation ponds are sulfate dominant; therefore, radium compounds formed during the relatively short life of the ponds would be expected to have low solubilities. The lack of Radium 226 in the ponds' water columns appear to support this theory.

## BACKGROUND

In early 1985, the State Water Resources Control Board found the evaporation and disposal of agricultural subsurface drainage water in Kesterson Reservoir to be hazardous to the environment and ordered the site cleaned up. The principal concern was the trace element selenium which was linked to waterfowl deaths and deformities at the site; however, data presented in the hearings also showed elevated levels of chromium, copper, nickel, zinc, and other trace elements in the drainage water entering Kesterson Reservoir. Concern was also expressed at the hearings that other sites within the San Joaquin Valley that were being used to store and evaporate agricultural subsurface drainage water were creating similar hazards to the environment.

Water quality surveys of the evaporation basins in question were conducted in December 1986 and June 1987 by the Central Valley Regional Water Quality Control Board (RWQCB). The purpose and results of the surveys are discussed in detail in "*Water and Sediment Quality in Evaporation Basins used for the Disposal of Agricultural Subsurface Drainage Water in the San Joaquin Valley, California*," (Westcot et al., 1988a) and "*Uranium Levels in Water in Evaporation Basins Used for the Disposal of Agricultural Subsurface Drainage Water in the San Joaquin Valley, California*," (Westcot et al., 1988b). Primarily, the information was used to begin the determination of baseline concentrations of selected elements in the basins and evaluate the concentrations as related to Chapter 15 of the California Code of Regulations (CCR), Title 23, Sections 2510-2601 and the Hazardous Waste Criteria found in CCR, Title 22, Section 66699 as it applies to the Toxics Pits Cleanup Act of 1984 (TPCA).

The surveys indicated that TPCA was not a concern for the majority of the ponds. However, since the surveys, adverse reproductive effects, including elevated rates of teratogenesis, reduced hatchability and complete reproductive failure have been reported for waterbirds using selected evaporation basins.

This report documents follow-up water quality surveys conducted by staff during 1988 and 1989 to characterize water quality in the basins and define the present concentrations of selenium and other trace elements found in the basins. Sediment sample results are included in a companion report entitled *Sediment Quality in Evaporation Basins Used for the Disposal of Agricultural Subsurface Drainage in the San Joaquin Valley, California, 1988 and 1989* (Chilcott et al., 1990). The study area and field and laboratory methods used for the water quality survey are described in the following sections along with a discussion of existing water quality in the basins.

An additional survey conducted by staff in 1990 will be presented in a separate report.

## STUDY AREA

Twenty-eight separate evaporation basins exist in different hydrogeologic areas of the San Joaquin Valley. The locations of these basins range from Gustine in the north to near Bakersfield in the south. The greatest concentration of basins lies along the edges of the former Tulare Lake Bed (Figure 1). Most of the evaporation basins (23) are privately-owned and serve individual farms. These twenty-three sites, however, make up only 55 percent of the ponded acreage. The

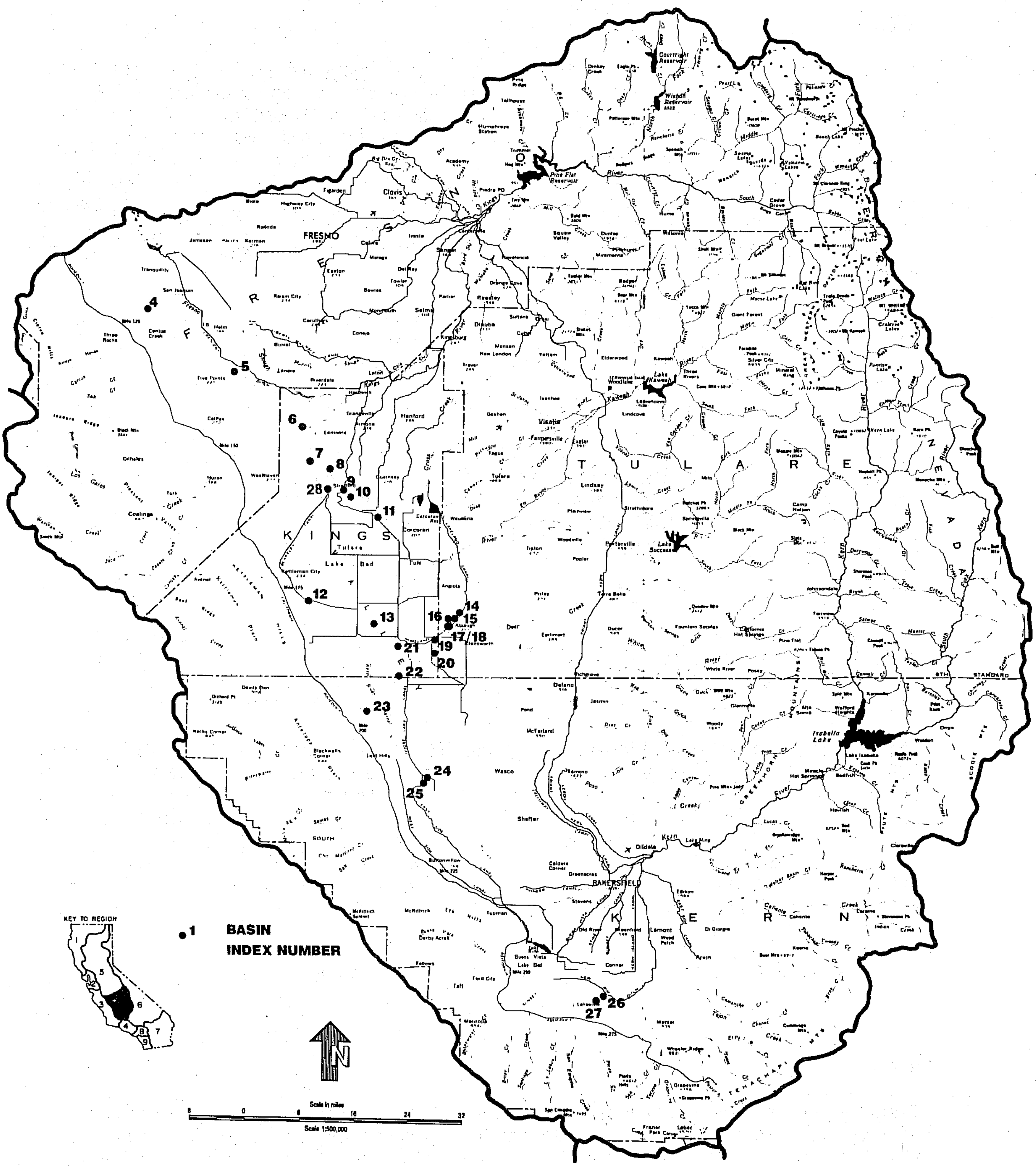



**FIG. 1. LOCATION OF AGRICULTURAL EVAPORATION BASINS IN THE TULARE BASIN.**

remaining 45 percent of the ponded acreage is operated by two drainage districts. Present facilities cover a total of 7,170 acres, with basin sizes ranging from 10 to 1,800 acres; however, six of the facilities are currently inactive (Table 1). The remaining 22 facilities have 80 individual cells and 46 inlets which result in a large variability in water quality. An additional 10,000 to 20,000 acres of evaporation basins are in various stages of planning and development, in the San Joaquin Valley; however, further development is being held until environmental issues are resolved.

The San Joaquin Valley evaporation basins consist of three types:

1. <u>In-series</u>

   Multiple cells within a basin.
   Single or multiple inflow points from drainage collection system.
   Increasingly concentrated water is routed to succeeding cells.
   Last cell or cells serve as final evaporation and salt deposition site.

2. <u>Unicellular-wet</u>

   Single-celled basin which does not evaporate to dryness.

3. <u>Unicellular-dry</u>

   Single-celled basin which evaporates to dryness each year.

Some basins are combinations of these three types due to operation and location of the inlets to the basin.

## FIELD SURVEYS AND DATA COLLECTION

Past inspections of each evaporation basin were conducted from 1 to 3 December 1986 and from 8 to 11 June 1987 (Westcot et al., 1988a). Current inspections were conducted from 7 to 8 June 1988 and from 6 to 7 June 1989. Not all basins were accessible or contained water during each survey period. Waterfowl use on the date of inspection was recorded along with field measurements of water depth, water temperature, and pH for each cell and inlet at the evaporation basin site.

Water quality samples were taken from each cell or subcell within an evaporation basin during each inspection. Similar samples were taken from each inlet to the basin. Samples for trace elements were collected in washed and nitric acid rinsed polyethylene bottles. Samples for minerals were collected in non-acid rinsed polyethylene containers. All sample bottles were rinsed three times with the basin water prior to collection. All samples were kept at approximately the basin water temperature prior to analysis. This procedure avoided mineral and trace element precipitation in these highly concentrated samples that might be caused by lower than ambient temperatures. None of the samples were filtered prior to analyses. All trace element samples were preserved to a pH <2 with ultra pure nitric acid within six hours of the actual collection from the basin or inlet.

Table 1. Characteristics of Evaporation Basins Located in the San Joaquin Valley

| BASIN NUMBER [1] | BASIN NAME | COUNTY | 1st YEAR OPERATION | BASIN SIZE (acres) | BASIN TYPE [2] | GEOLOGIC SETTING [3] | CELLS [4] | INLETS [5] |
|---|---|---|---|---|---|---|---|---|
| 1 | Souza | Merced | unknown | 10 | 2 | Basin | 1 | 4 |
| 2 * | Lindemann | Merced | unknown | 100 | 2 | Basin | 1 | 1 |
| 3 * | Britz South Dos Palos | Merced | 1985 | 50 | 1 | Basin | 2 | 1 |
| 4 | Sumner Peck | Fresno | 1984 | 120 | 1 | Alluvial | 6 | 3 |
| 5 | Britz Deavenport - Five Points | Fresno | 1982 | 20 | 2 | Alluvial | 2 | 1 |
| 6 | Stone Land Company | Kings | 1984 | 200 | 2 | Basin | 3 | 5 |
| 7 * | Carlton Duty | Kings | 1983 | 80 | 2 | Basin | 1 | 2 |
| 8 | Westlake 1 & 2 (North) | Kings | 1984 | 260 | 2 | Basin | 2 | 3 |
| 9 | Meyers Ranch | Kings | 1983 | 80 | 1 | Basin | 3 | 1 |
| 10 | Barbizon Farms | Kings | 1985 | 70 | 2 | Basin | 1 | 2 |
| 11 | TLDD North | Kings | 1974 | 265 | 1 | Lake | 7 | 1 |
| 12 | Westlake 3 (South) | Kings | 1984 | 740 | 1 | Lake | 6 | 2 |
| 13 | Liberty Farms (J-W Farms) | Kings | 1981 | 640 | 3 | Lake | 4 | 5 |
| 14 | Pryse Farms | Tulare | 1985 | 80 | 1 | Lake | 2 | 1 |
| 15 | Bowman Farms | Tulare | 1981 | 70 | 3 | Lake | 3 | 2 |
| 16 | Morris Farms | Tulare | 1985 | 40 | 3 | Lake | 1 | 1 |
| 17 | Martin Farms | Tulare | 1985 | 15 | 2 | Lake | 1 | 1 |
| 18 * | Smith Farms | Tulare | 1985 | 10 | 3 | Lake | 1 | 1 |
| 19 | Four - J Corporation | Kings | 1985 | 30 | 3 | Lake | 1 | 2 |
| 20 * | Nickell | Kings | 1985 | 20 | 3 | Lake | 1 | 1 |
| 21 | TLDD Hacienda Ranch | Kings | 1978 | 1100 | 1 | Lake | 8 | 1 |
| 22 | TLDD South | Kings/Kern | 1978 | 1800 | 1 | Lake | 11 | 1 |
| 23 | Lost Hills (Westfarmers) | Kern | 1984 | 790 | 1 | Alluvial | 4 | 3 |
| 24 | Carmel Ranch (Willow Creek) | Kern | 1972 | 300 | 1 | Lake | 6 | 3 |
| 25 | Lost Hills Ranch | Kern | 1981 | 100 | 1 | Lake | 3 | 1 |
| 26 | Rainbow Ranch (Sam Andrews) | Kern | 1983 | 105 | 1 | Alluvial | 4 | 2 |
| 27 * | Chevron Land Company | Kern | 1985 | 65 | 1 | Alluvial | 4 | 2 |
| 28 # | Fabry | Kings | unknown | 10 | 2 | Basin | 1 | 1 |

[1] Basin number corresponds to identification numbers used in Figure 1.

[2] Basin Types are: 1) in-series; 2) uni-cellular - remains wet year round; 3) uni-cellular - evaporates to dryness annually (see text for more detail)

[3] Geologic Setting: Site underlain by Alluvial Fan, Basin Trough, or Lake Bed type sedimentary deposits (see text for more detail)

[4] Cells are separate evaporation units. Cells in at least 7 basins are further divided into subcells by windbreaks, levees, or multiple inlets. The total number of cells + subcells is 109.

[5] Multiple inlets may exist within individual cells or basins: see individual site descriptions for further details.

* not currently active

\# not sampled during 1988 or 1989

The only exception to this procedure occurred during the June 1988 survey. An additional pint of water was collected at each sampling location and was not filtered or acidified. These samples were kept at ambient temperature in a darkened container until delivery to the Department of Soil and Environmental Sciences, University of California, Riverside, for trace element analyses using chelation and Inductivity Coupled Argon Plasma (ICP) procedures (Bradford and Bahktar, 1990).

Sediment samples were also collected during the two surveys. Data for the sediment may be found in a companion report entitled *Sediment Quality in Evaporation Basins Used for the Disposal of Agricultural Subsurface Drainage in the San Joaquin Valley, California, 1988 and 1989 (Chilcott et al., 1990).*

A quality control and quality assurance program was conducted during each survey. For the water analysis, spike and duplicate samples, as well as internal standards, were utilized in the laboratory. Ten percent blind duplicate samples were submitted to the laboratory with 50 percent of these being spiked with known concentrations. Reported results fall within quality assurance tolerance guidelines for both water and sediment analysis and are on file at the Sacramento Regional Water Quality Control Board office.

## RESULTS OF WATER QUALITY ANALYSES

Table 2 lists all analyses performed on evaporation pond water collected between 1986 and 1989. The most thorough analyses were conducted during the 1988 season. Of the 40 elements investigated, a number of concentrations fell either below analytical detection limits or compared favorably with seawater backgrounds (Table 3). Elements which do appear at elevated concentrations include arsenic, boron, molybdenum, selenium, uranium, vanadium, sulfate, and total dissolved solids.

A summary of the analyses for standard mineral and trace elements in water samples collected during 1988 and 1989 at evaporation basin sites by Regional Board staff for both inlet and basin cell water are given in Tables 4 through 7. Full data sets are presented in Appendix A and B for standard minerals and trace elements, respectively. It must be recognized that the results presented here are for grab samples collected in each basin or inlet and do not reflect the daily or seasonal variability within each basin cell or inlet.

### Inlets

Regional Board staff collected water quality samples from 23 and 27 inlets during the June 1988 and June 1989 surveys, respectively. As was found during previous surveys in 1986 and 1987 (Westcot et al., 1988a), the water discharged into the basins was predominantly a sodium sulfate or sodium sulfate-chloride type water (Figure 2). Major constituent concentrations continue to vary widely (Table 8).

Specific conductance (EC) of the inlet samples ranged from 790 to 55,000 $\mu$mhos/cm. Total dissolved solids (TDS) values ranged from 450 to 57,000 mg/L. Geometric means during 1988 and 1989 for EC and TDS were 14,100 $\mu$mhos/cm and 10,400 mg/L respectively, while for 1986 and 1987, the values were 18,300 $\mu$mhos/cm and 15,300 mg/L respectively. The geometric means reported for TDS

Table 2. Analyses Performed on Evaporation Pond Water 1986 - 1989.

| TRACE ELEMENTS | MINERALS | OTHER |
|---|---|---|
| Aluminum* | Calcium | Total Dissolved Solids |
| Antimony* | Magnesium | Electrical Conductivity |
| Arsenic | Sodium | pH |
| Barium* | Phosphorus | Water Temperature |
| Beryllium* | Potassium | |
| Bismuth* | Chloride | |
| Boron | Silica* | |
| Cadmium | Sulfate | |
| Chromium | Bicarbonate | |
| Copper | Carbonate | |
| Gallium* | | |
| Germanium* | | |
| Gold* | | |
| Iron | | |
| Lead | | |
| Lithium* | | |
| Manganese | | |
| Mercury | | |
| Molybdenum | | |
| Nickel | | |
| Radium | | |
| Scandium* | | |
| Selenium | | |
| Silver | | |
| Strontium* | | |
| Tellurium* | | |
| Tin* | | |
| Titanium* | | |
| Uranium | | |
| Vanadium | | |
| Zinc | | |

* Analysis only conducted on 1988 samples (Bradford and Bahktar, 1990).

Table 3. Comparison of Average Evaporation Pond Inlet Water Concentrations with Sea Water Concentrations. 1/

| TRACE ELEMENTS | | | MINERALS | | | OTHER | | |
|---|---|---|---|---|---|---|---|---|
| | Inlet Water | Sea Water | | Inlet Water | Sea Water | | Inlet Water | Sea Water |
| | (ug/L) | (ug/L) | | (mg/L) | (mg/L) | | | |
| Al* | 420 | 160-1,900 [1] | Ca | 240 | [410] | TDS | 10,500 | 31,000 |
| Sb* | <1 | [0.3] | Mg | 270 | [1,400] | EC | 14,100 | ND |
| As | 49 | [3] | Na | 3,200 | [10,500] | pH | 8.1 | 7.9 |
| Ba* | 8 | 50 [20] | P* | 0.360 | [0.09] | | | |
| Be* | <1 | <0.01 | K | 12 | [390] | | | |
| Bi* | <1 | 0.2 [.02] | Cl | 430 | [19000] | | | |
| B | 9,000 | [4,500] | Si* | 20 | 0.02-4.0 [6.4] | | | |
| Cd* | <1 | [0.11] | SO4 | 4,500 | [2,700] | | | |
| Cr* | 1 | [0.05] | HCO3 | 430 | [140] | | | |
| Cu* | 7 | 1.0-90 [3] | CO3 | <1 | ND | | | |
| Ga* | <1 | 0.5 [0.03] | | | | | | |
| Ge* | <5 | present [0.07] | | | | | | |
| Au* | <5 | 0.004-0.008 [.01] | | | | | | |
| Fe* | 26 | 2-20 [3] | | | | | | |
| Pb* | 2 | 4-5 [0.03] | | | | | | |
| Li* | 56 | [170] | | | | | | |
| Mn* | 84 | 1-10 [2] | | | | | | |
| Hg* | <1 | [0.2] | | | | | | |
| Mo | 550 | 0.3-2 [10] | | | | | | |
| Ni* | 4 | 0.1-0.5 [7] | | | | | | |
| Sc* | <10 | [<.04] | | | | | | |
| Se | 7 | 4 [0.1] | | | | | | |
| Ag* | <5 | 0.15-0.3 [0.3] | | | | | | |
| Sr* | 5,300 | 13,000 [8,000] | | | | | | |
| Te* | <1 | ND | | | | | | |
| Sn* | <100 | 3 [0.8] | | | | | | |
| Ti* | <100 | present [1] | | | | | | |
| U | 190 | 0.15-1.6 [3] | | | | | | |
| V | 103 | 0.3 [2] | | | | | | |
| Zn* | 6 | 5-14 [10] | | | | | | |
| Ra | 0.1 | (2.00E-8) - (3.00E-7) | | | | | | |

1/ From Handbook of Chemistry and Physics; 51st Edition, 1970-1971.
[ ] From Hem, J.D., 1985. Study and Interpretation of the Chemical Characteristics of Natural Water.

ND = No Data

* Analyzed by the University of California, Riverside.

Table 4. 1988 Levels of Selected Constituents in Inflow to Agricultural Drainage Water Evaporation Basins in the San Joaquin Valley, California**

| Basin | Total Dissolved Solids (mg/L) | Boron (mg/L) | Arsenic (ug/L) | Molybdenum (ug/L) | Selenium (ug/L) | Uranium (ug/L) | Vanadium (ug/L) |
|---|---|---|---|---|---|---|---|
| 1. Souza | 450-740 | 0.3-0.9 | ND | ND | ND | ND | ND |
| 3. Britz SDP | 4,500 | 7.6 | ND | ND | ND | ND | ND |
| 4. Sunmer Peck | 8,000 | 4.7 | <5 | 40 | 757 | 97 | 9 |
| 6. Stone Land Co. | 8,900-21,000 | 10-36 | 6-<10 | 198-785 | 1.6-4.3 | 33-110 | 7-<10 |
| 7. Carlton Duty | 49,000 | 31.0 | <20 | 459 | 13 | 530 | 11 |
| 8. Westlake, North | 23,000-24,000 | 9.6-10 | 44-46 | 261-272 | 1-1.1 | 150-160 | 66-69 |
| 9. Meyers Ranch | 7,000 | 2.7 | <5 | 182 | 1 | 83 | 23 |
| 10. Barbizon Farms | 9,200-16,000 | 4.2-7.3 | 35-36 | 300-664 | 1.3-1.4 | 210-280 | 72-95 |
| 11. TLDD, North | 4,800 | 2.8 | 180 | 209 | 2.6 | 79 | 154 |
| 14. Pryse Farms | 25,000 | 8.9 | 320 | 1,530 | 9.6 | 510 | 229 |
| 15. Bowman Farms | 49,000 | 14.0 | 220 | 2,835 | 13 | 570 | 172 |
| 16. Morris Farms | 17,000 | 8.6 | 240 | 2,145 | 54 | 1,100 | 194 |
| 17. Martin Farms | 18,000 | 9.1 | 250 | 2,600 | 60 | 1,200 | 166 |
| 22. TLDD, South | 9,000 | 5.5 | 120 | 1,065 | 30 | 460 | 85 |
| 23. Lost Hills WD | 14,000 | 29.0 | <10 | 796 | 142 | 120 | 24 |
| 25. Lost Hills Ranch | 14,000 | 9.0 | 560 | 2,760 | 2.4 | 200 | 228 |

* Minimum detection levels vary with salinity.

** All values reported as total recoverable.

TLDD Tulare Lake Drainage District.

ND No Data

Table 5. 1989 Levels of Selected Constituents in Inflow to Agricultural Drainage Water Evaporation Basins in the San Joaquin Valley, California**

| Basin | Total Dissolved Solids (mg/L) | Boron (mg/L) | Arsenic (ug/L) | Molybdenum (ug/L) | Selenium (ug/L) | Uranium (ug/L) | Vanadium (ug/L) |
|---|---|---|---|---|---|---|---|
| 1. Souza | 830 | 1.4-3.9 | 5-6 | 4-9 | 1.0-2.8 | 6-18 | 15-18 |
| 6. Stone Land Co. | 7,400-23,000 | 9.8-38 | 4-5 | 229-681 | 2.3-7.4 | 31-95 | 9-21 |
| 7. Carlton Duty | 57,000 | 38 | 6 | 548 | 10.6 | 160 | 11 |
| 8. Westlake, North | 26,000-44,000 | 13-24 | 30-45 | 290-620 | 0.4-0.6 | 170-190 | 54-56 |
| 9. Meyers Ranch | 4,800 | 2.6 | 14 | 134 | 0.8 | 45 | 22 |
| 10. Barbizon Farms | 7,800 | 4.9 | 60 | 334 | 1.7 | 185 | 96 |
| 11. TLDD, North | 3,400 | 2.7 | 150 | 163 | 2.0 | 70 | 190 |
| 12. Westlake #3 | 16,000 | 9 | 120 | 338 | 6.5 | 130 | 14 |
| 13 J & W farms | 6,400 | 4.7 | 27 | 473 | 10 | 330 | 30 |
| 14. Pryse Farms | 23,000 | 11 | 420 | 1600 | 9.9 | 560 | 245 |
| 15. Bowman Farms | 39,000 | 13 | 250 | 2885 | 19 | 650 | 161 |
| 16. Morris Farms | 17,000 | 9.9 | 220 | 2340 | 62 | 1200 | 165 |
| 17. Martin Farms | 12,000 | 8.4 | 280 | 1995 | 38 | 900 | 155 |
| 19. 4-J Corp. | 9,100-18,000 | 14-25 | 480-1400 | 596-6575 | 14-43 | 470-3100 | 219-943 |
| 22. TLDD, South | 7,600 | 5.4 | 98 | 938 | 21 | 500 | 65 |
| 23. Lost Hills WD | 1,600-29,000 | 43-63 | <5 * | 745-1207 | 83-671 | 110-280 | 19-22 |
| 24. Carmel Ranch | 9,200-13,000 | 10-19 | 360-560 | 1285-2325 | 0.8-4.6 | 290-820 | 143-285 |
| 25. Lost Hills Ranch | 11,000 | 8.8 | 320 | 2095 | 2.1 | 160 | 246 |
| 26. Sam Andrews | 21,000 | 35 | 6 | 1685 | 212 | 280 | 5 |

* Minimum detection levels vary with salinity.

** All values reported as total recoverable.

TLDD Tulare Lake Drainage District.

ND No Data

Table 6. 1988 Levels of Selected Constituents in Drainage Water Evaporation Basins in the San Joaquin Valley, California **

| Basin | Total Dissolved Solids (mg/L) | Boron (mg/L) | Arsenic (ug/L) | Molybdenum (ug/L) | Selenium (ug/L) | Uranium (ug/L) | Vanadium (ug/L) |
|---|---|---|---|---|---|---|---|
| 1. Souza | 800 | 1 | ND | ND | ND | ND | ND |
| 3. Britz SDP | 5,800 | 10 | ND | ND | ND | ND | ND |
| 4. Sunmer Peck | 12,000-48,000 | 7.5-39 | <10-<20* | 90-422 | 685-2,207 | 160-720 | 14-24 |
| 5. Britz-Deav 5 Pts. | 18,000-20,000 | 34-37 | <10 | 272-282 | 74-79 | 61-63 | 3-4 |
| 6. Stone Land Co. | 22,000-160,000 | 27-170 | 4-<40 | 320-962 | 1-4.8 | 41-220 | 7-52 |
| 7. Carlton Duty | 210,000 | 200 | <50 | 1,285 | 13 | 120 | 24 |
| 8. Westlake, North | 43,000-110,000 | 19-57 | 70-130 | 442-1,840 | 1.1-1.7 | 210-480 | 41-68 |
| 9. Meyers Ranch | 12,000-16,000 | 5-6.7 | <10-13 | 272-432 | 0.3-0.5 | 43-54 | 4-8 |
| 10. Barbizon Farms | 17,000-31,000 | 8.3-14 | <20-40 | 484-872 | 0.5-1.5 | 220-260 | 11-64 |
| 11. TLDD, North | 3,800-18,000 | 2.4-11 | 140-400 | 173-582 | 1.0-2.1 | 60-200 | 6-271 |
| 12. Westlake #3 | 20,000-98,000 | 8.5-52 | 37-230 | 402-678 | 5.4-16 | 130-290 | 8-15 |
| 14. Pryse Farms | 47,000-86,000 | 19-36 | 540-1,100 | 2,740-4,325 | 9.4-11 | 570-1,100 | 80-137 |
| 15. Bowman Farms | 52,000-74,000 | 14-24 | <30 | 4,280-6,465 | 13-33 | 400-600 | 9-<20 |
| 16. Morris Farms | 42,000 | 18 | 30 | 3,565 | 23 | 460 | 18 |
| 17. Martin Farms | 32,000 | 19 | 100 | 4,350 | 37 | 910 | 38 |
| 19. 4-J Corp. | 53,500 | 51 | 3,100 | 4,080 | 50 | 2,400 | 490 |
| 21. TLDD Hacienda | 8,400-130,000 | 5-72 | 11-405 | 920-5,860 | 12-41 | 370-2,600 | 10-68 |
| 22. TLDD, South | 13,000-140,000 | 8.7-99 | 6-500 | 1,045-7,600 | 3.4-20 | 370-3,100 | 7-53 |
| 23. Lost Hills WD | 31,000-110,000 | 61-170 | <20-<50 | 1,170-3,480 | 102-603 | 180-480 | 33-73 |
| 24. Carmel Ranch | 17,000-147,000 | 20-325 | 330-3,950 | 2,425-22,850 | 2.1-4.6 | 770-10,000 | 87-489 |
| 25. Lost Hills Ranch | 13,000-21,000 | 10-16 | 660-1,200 | 2,815-4,805 | 2.8-3.8 | 200-360 | 216-223 |
| 26. Sam Andrews' Sons | 25,000-160,000 | 37-290 | <20-<50 | 1,825-12,300 | 239-1,193 | 340-2,200 | 6-42 |

* Minimum detection levels vary with salinity.

** All values reported as total recoverable.

TLDD Tulare Lake Drainage District.

ND No Data

Table 7. 1989 Levels of Selected Constituents in Drainage Water Evaporation Basins in the San Joaquin Valley, California**

| Basin | Total Dissolved Solids (mg/L) | Boron (mg/L) | Arsenic (ug/L) | Molybdenum (ug/L) | Selenium (ug/L) | Uranium (ug/L) | Vanadium (ug/L) |
|---|---|---|---|---|---|---|---|
| 1. Souza | 1,050 | 1.9 | 6 | 6 | 1.1 | 9 | 18 |
| 4. Sumner Peck | 5,100-395,000 | 37-700 | 11-420 | 620-4,515 | 323-6,280 | 340-8,000 | 23-61 |
| 5. Britz-Deav 5 Pts. | 19,000-21,000 | 43-46 | 3-8 | 318-324 | 55-60 | 55-69 | 4-26 |
| 6. Stone Land Co. | 51,000-240,000 | 38-340 | 5-110 | 411-2,230 | 0.8-6.9 | 40-440 | 6-30 |
| 7. Carlton Duty | 280,000 | 240 | 54 | 1,780 | 11 | 580 | 22 |
| 8. Westlake, North | 42,000-48,000 | 25-30 | 86-93 | 640-687 | 0.7-5.4 | 200-220 | 32 |
| 9. Meyers Ranch | 16,000-22,000 | 7.1-10 | 12-14 | 459-678 | 0.6-1.0 | 6-20 | 1-<5 |
| 10. Barbizon Farms | 20,000 | 17 | 69 | 945 | 2.0 | 340 | 74 |
| 11. TLDD, North | 3,400-25,000 | 2.6-17 | 170-720 | 162-841 | 0.9-1.9 | 34-310 | 2-194 |
| 12. Westlake #3 | 36,000-55,000 | 19-56 | 110-250 | 522-810 | 6.4-13 | 160-360 | 8-25 |
| 13 J & W farms | 7,500 | 4.6 | 23 | 878 | 27 | 740 | 24 |
| 14. Pryse Farms | 59,000 | 24 | 730 | 3,035 | 17 | 700 | 126 |
| 15. Bowman Farms | 10,000-29,000 | 4.9-10 | 58-190 | 845-2,370 | 2.5-17 | 140-620 | 36-232 |
| 16. Morris Farms | 43,000 | 23 | 150 | 3,860 | 49 | 1,100 | 47 |
| 17. Martin Farms | 43,000 | 37 | 36 | 5,495 | 22 | 570 | 11 |
| 19. 4-J Corp. | 50,000 | 75 | 5,100 | 5,375 | 38 | 2,700 | 469 |
| 21. TLDD Hacienda | 9,450-135,000 | 6.3-87 | 29-750 | 973-6,678 | 11-17 | 220-3,000 | 7-27 |
| 22. TLDD, South | 10,000-130,000 | 7.3-120 | 100-710 | 985-8,310 | 10-18 | 270-3,200 | 11-66 |
| 23. Lost Hills WD | 10,000-165,000 | 42-270 | <5-59 * | 434-5,383 | 29-539 | 110-790 | 15-112 |
| 24. Carmel Ranch | 19,000-360,000 | 26-630 | 410-14,000 | 3,215-44,100 | 1.4-5.6 | 760-22,300 | 35-259 |
| 25. Lost Hills Ranch | 1,900-33,000 | 10-27 | 800-2,400 | 2,510-7,080 | 1.9-4.7 | 190-590 | 147-272 |
| 26.Sam Andrews' Sons | 21,000-160,000 | 35-280 | <5-27 | 1,685-12,100 | 130-1,019 | 280-1,800 | 7-37 |

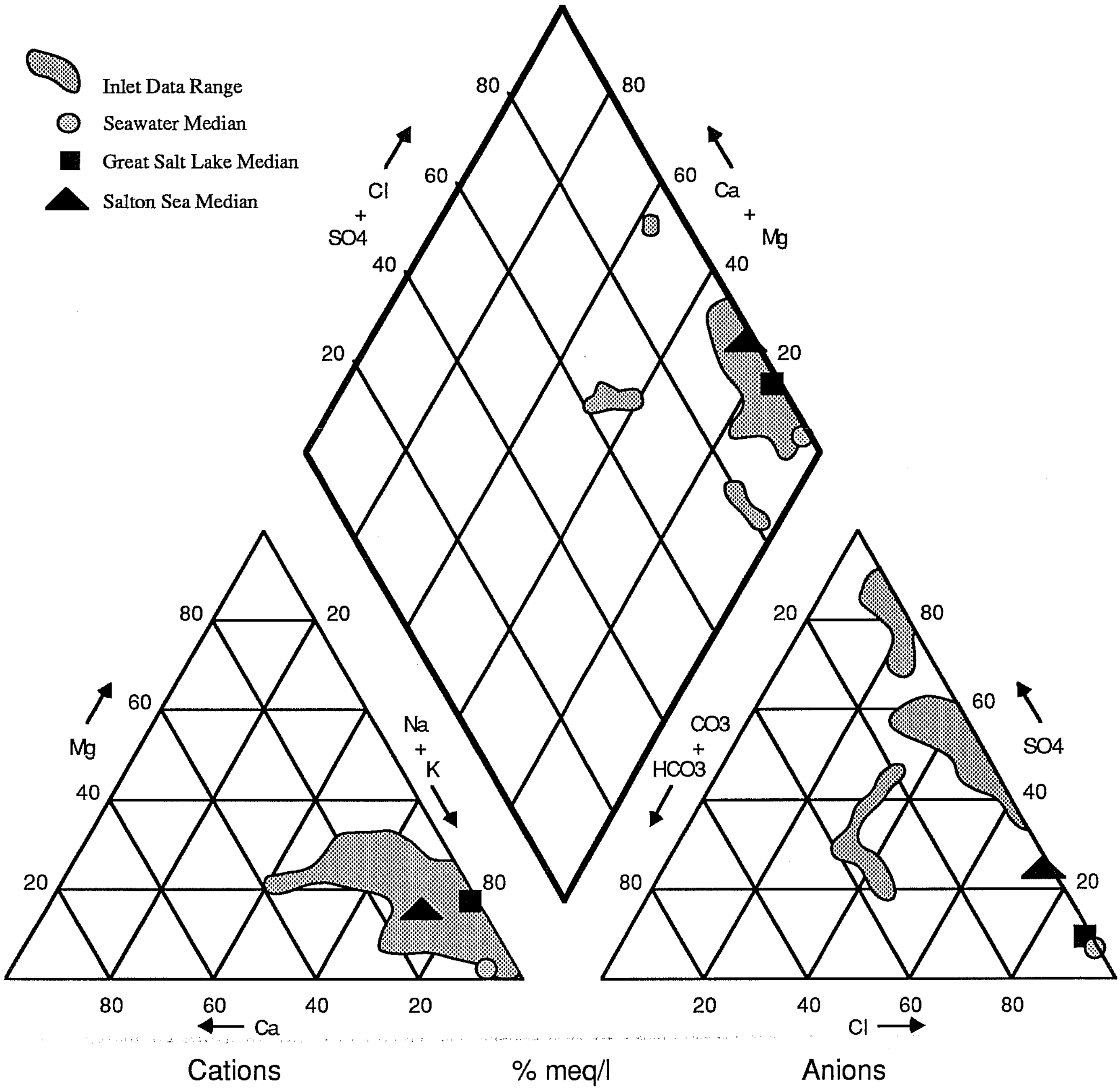
* Minimum detection levels vary with salinity.

** All values reported as total recoverable.

TLDD Tulare Lake Drainage District.

ND No Data

Figure 2. Chemical Composition of Inlet Water to the Evaporation Basins as Compared to Three Natural Salt Sinks, 1988-1989.



fall below the mean of seawater, 31,000 mg/L. However, the high value of 57,000 mg/L almost doubles the seawater concentration.

Trace element concentrations varied widely between the basin inlets. Only those elements with excessively high relative concentrations will be discussed here: selenium, arsenic, boron, molybdenum, uranium, and vanadium.

Selenium concentrations ranged from <1 to 750 $\mu$g/L. High concentrations (>100 $\mu$g/L) were found in two inlets in 1988 and three inlets during 1989. During 1988 and once in 1989, consistently high concentrations occurred in the inflow to Lost Hills Water District. One of the Lost Hills Water District inlets with elevated levels in 1988, was not flowing during the 1989 survey. During 1989, inlets at Sumner Peck and Sam Andrews also contained >100 $\mu$g/L selenium. Over 50 percent of the total samples collected had selenium concentrations under 10 $\mu$g/L, the current drinking water criterion. Figure 3 depicts selenium ranges in the inlets during three time periods, 1985 to 1987, 1988 and 1989. Overall ranges have not appeared to change with time.

Arsenic concentrations also ranged widely with a low value of 3 $\mu$g/L and a high of 1,400 $\mu$g/L. The geometric mean was 38 $\mu$g/L, almost thirteen times the geometric mean of seawater (3 $\mu$g/L). Figure 4 does indicate a trend of increasing arsenic concentrations. Between 1985 and 1989, there has been a 15 percent increase in the number of inlets with arsenic concentrations exceeding 200 $\mu$g/L. These results have not yet been compared statistically.

Boron concentrations have remained fairly consistent in the inlets over time. During 1988 and 1989, values ranged from 0.3 to 63 mg/L with a geometric mean of 9 mg/L. Average seawater concentration is 4.5 mg/L. Over 50 percent of the sumps tested during 1988 and 40 percent of the sumps in 1989 had concentrations less than 10 mg/L (Figure 5).

Molybdenum and uranium concentrations have been found to be fairly well correlated for the inlet water (Figure 6); however, actual concentrations varied greatly. Molybdenum values ranged from 4 to 6,600 $\mu$g/L with a geometric mean of 550 $\mu$g/L which is 55 times the mean concentration found in seawater (10 $\mu$g/L). Uranium values ranged from 6 to 3,100 $\mu$g/L with a geometric mean of 190 $\mu$g/L, over 60 times the mean concentration found in seawater (3 $\mu$g/L). The number of inlets reported as falling within selected concentration ranges has remained consistent for both elements between 1985 and 1989 (Figures 7 and 8). Although none of the inlets had molybdenum concentrations less than 100 $\mu$g/L during 1989, between 1985 and 1988, 10 percent of the inlets contained <100 $\mu$g/L molybdenum. In 1989, 60 percent of the inlet molybdenum concentrations fell within the range of 100 $\mu$g/L to 1000 $\mu$g/L while the remaining 40 percent had concentrations exceeding 1000 $\mu$g/L. Inlet uranium concentration distributions remained consistent over the years with approximately 30 percent exceeding 400 $\mu$g/L.

Vanadium inlet water concentrations ranged from 5 $\mu$g/L to 943 $\mu$g/L. The geometric mean for the inlet water (54 $\mu$g/L) greatly exceeded the reported mean for seawater (2 $\mu$g/L). Vanadium analyses were only conducted during the 1988 and 1989 surveys. Figure 9 depicts the concentration distributions for the two years. The percent of inlets containing less than 50 $\mu$g/L vanadium remained at approximately 40 percent for both years. An 8 percent increase was noted between 1988 and 1989, in the number of inlets containing greater than 200 $\mu$g/L,

Figure 3. Frequency Distribution of Selenium in Inlets to Agricultural Subsurface Drainage Water Evaporation Basins.

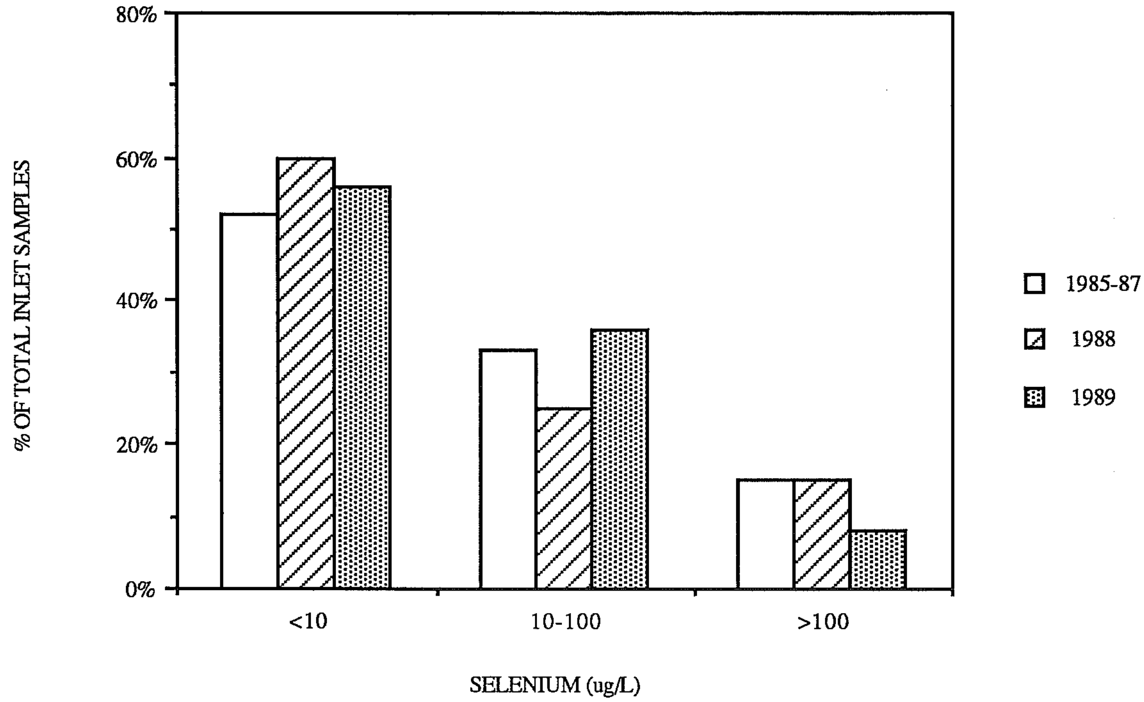



Figure 4. Frequency Distribution of Arsenic in Inlets to Agricultural Subsurface Drainage Water Evaporation Basins.

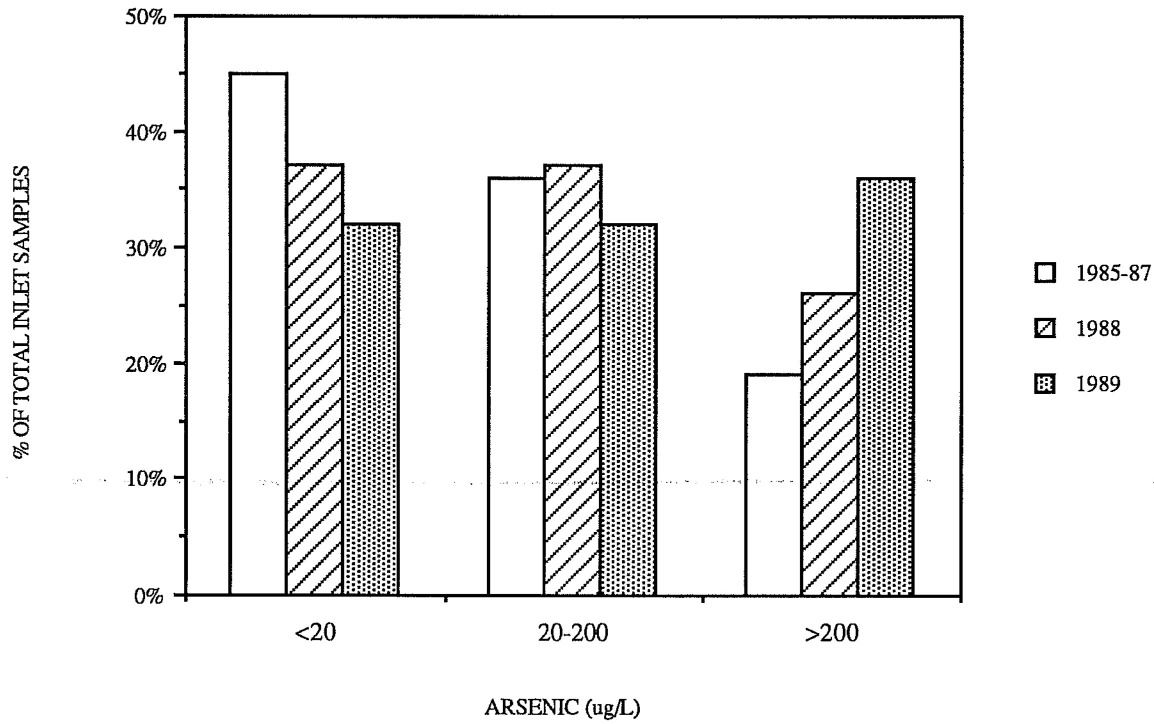


Figure 5. Frequency Distribution of Boron in Inlets to Agricultural Subsurface Drainage Water Evaporation Basins.

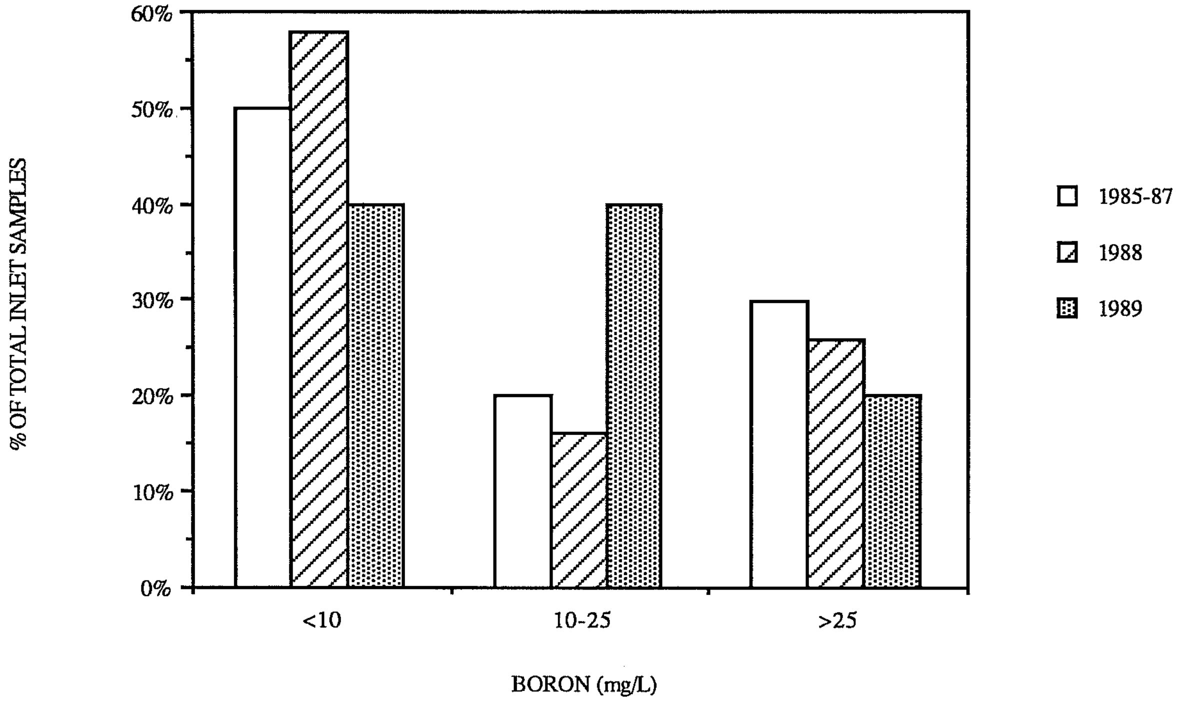



Figure 6. Correlation of Molybdenum and Uranium in Agricultural Subsurface Drainage Water Inlets, 1988 and 1989.

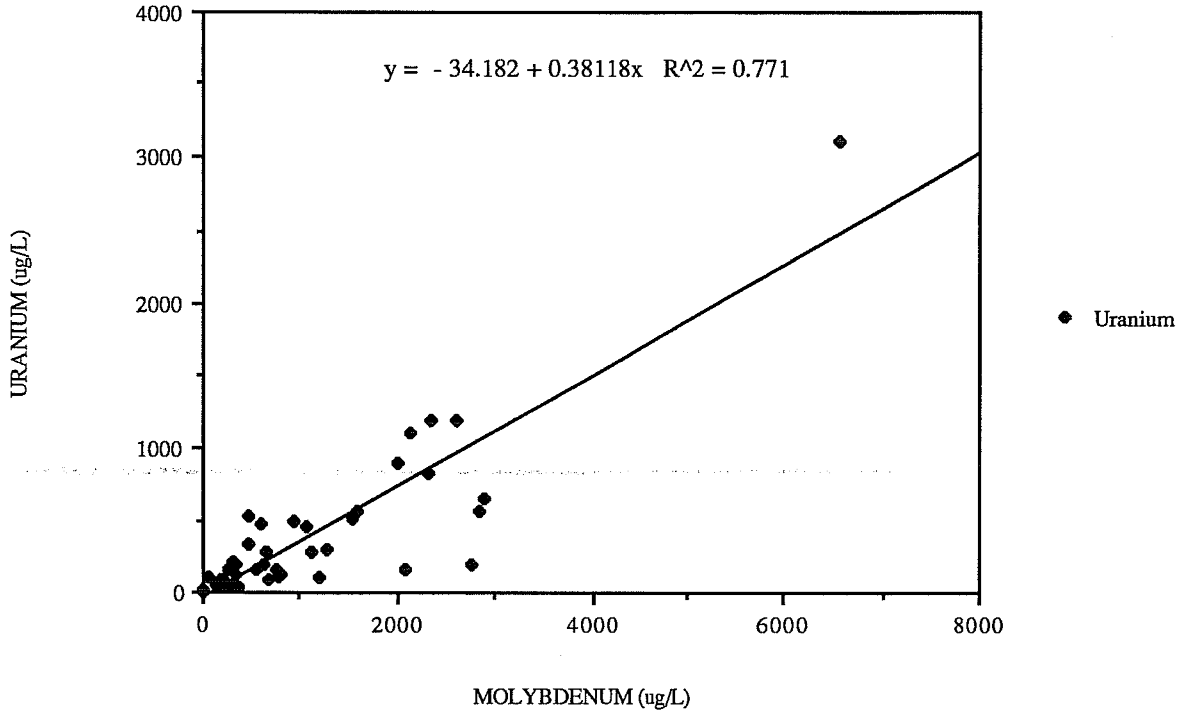


Figure 7. Frequency Distribution of Molybdenum in Inlets to Agricultural Subsurface Drainage Water Evaporation Basins.

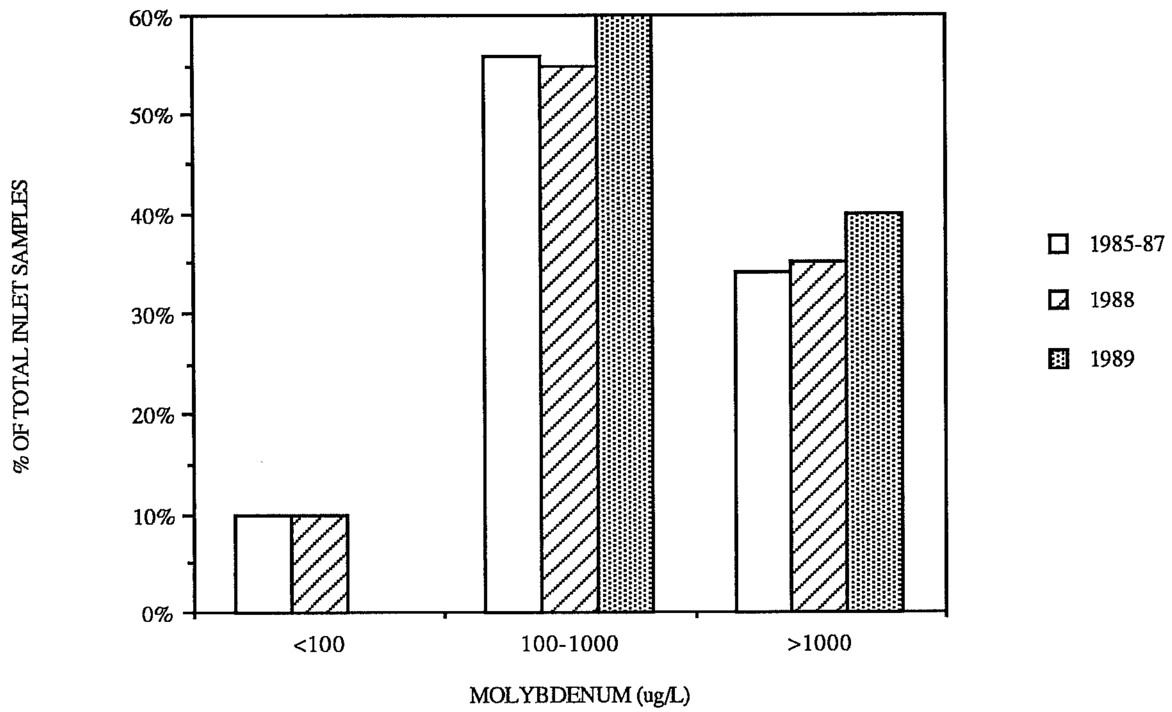
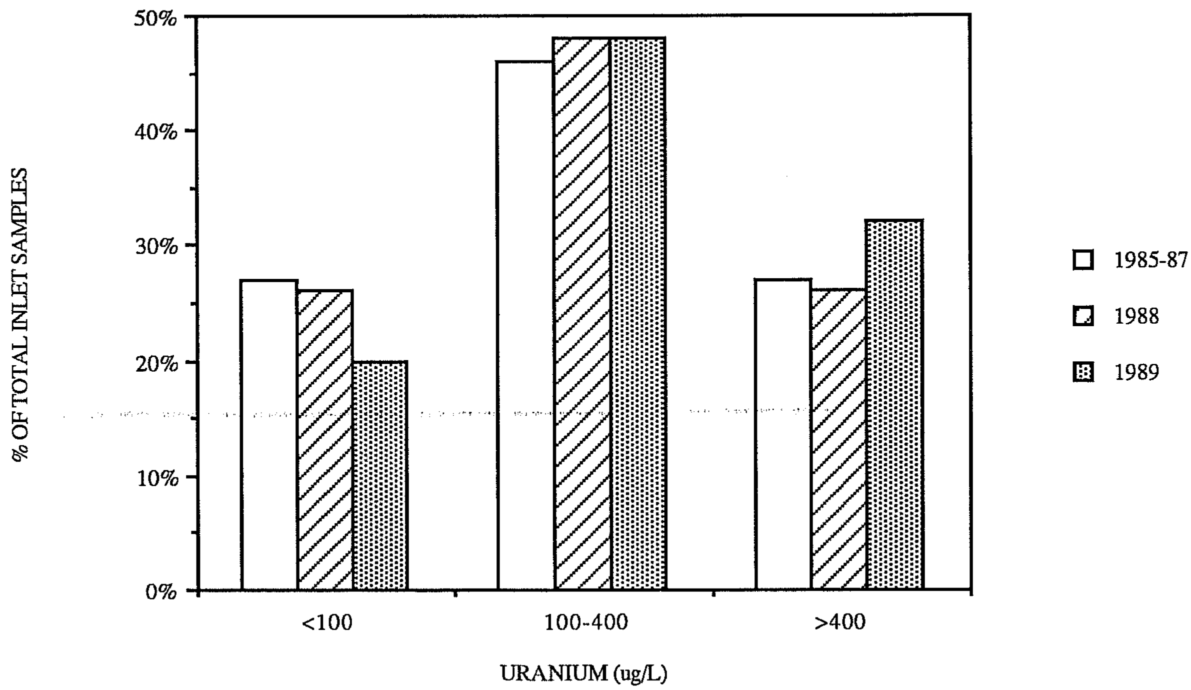



Figure 8. Frequency Distribution of Uranium in Inlets to Agricultural Subsurface Drainage Water Evaporation Basins.



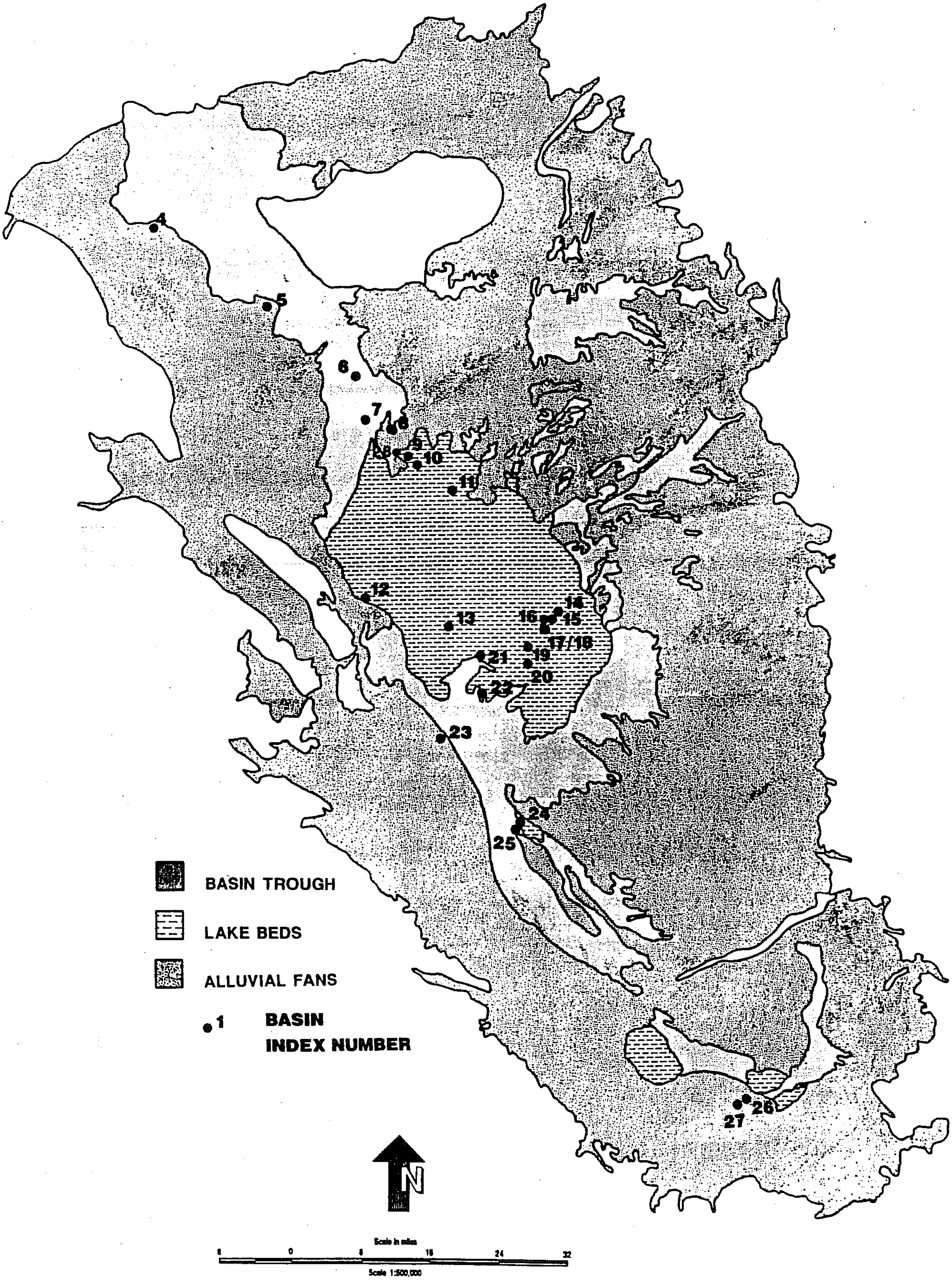
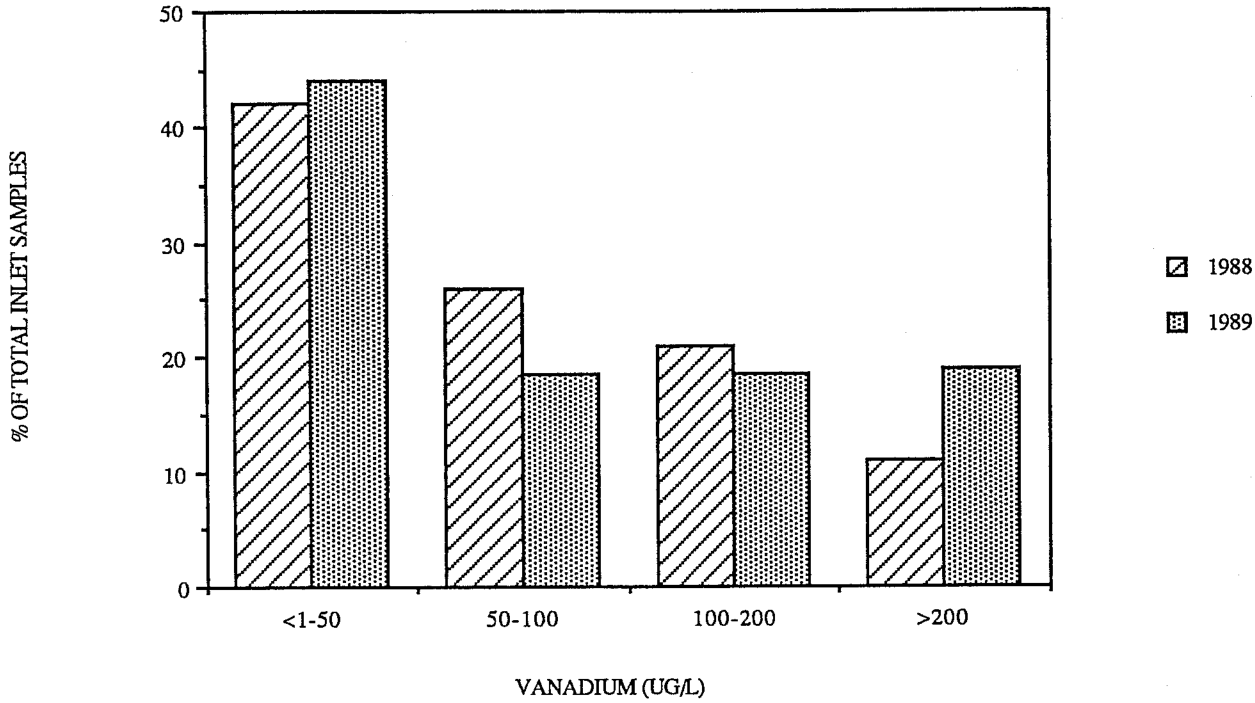



**Figure 8. Location of Agricultural Evaporation Basins in Geologic Settings of the Tulare Basin (Taken from Westcot et al., 1988a)**

Figure 9. Frequency Distribution of Vanadium in Inlets to Evaporation Basins Used for the Disposal of Agricultural Subsurface Drainage Water




bringing the total to 20 percent. The increasing trend will continue to be monitored in future surveys.

**Basins**

Regional Board staff collected water quality samples from 99 and 91 basin cells and subcells during the June 1988 and June 1989 surveys, respectively. As was found in the previous 1986 and 1987 surveys (Westcot, et al., 1988), water collected from the basin cells showed sodium, sulfate, and in certain areas, chloride as the major ions. As in the inlets, the water in the basins was a sodium sulfate or sodium sulfate-chloride type water (Figure 10). The concentrations of the major constituents varied widely (Table 8).

During 1988 and 1989, Regional Board staff sampled thirteen natural saline lakes in the Western United States (Westcot et al., 1990). These natural saline lakes provide data for comparison with the evaporation basins. A summary of the saline lake data is presented alongside the evaporation basin data in Table 8.

The salt concentrations in the basin samples varied widely and, as expected, were higher than the respective influent samples due primarily to evaporative concentration of dissolved constituents. The total dissolved solids (TDS) concentrations for the basin samples for 1988 and 1989 ranged from 800 to 395,000 mg/L. The 1986 and 1987 values ranged from 2,675 to 388,000 mg/L. The large variability in total dissolved solids is partly due to extensive

Figure 10. Chemical Composition of Water in Evaporation Basins as Compared to Three Natural Salt Sinks, 1988-1989.

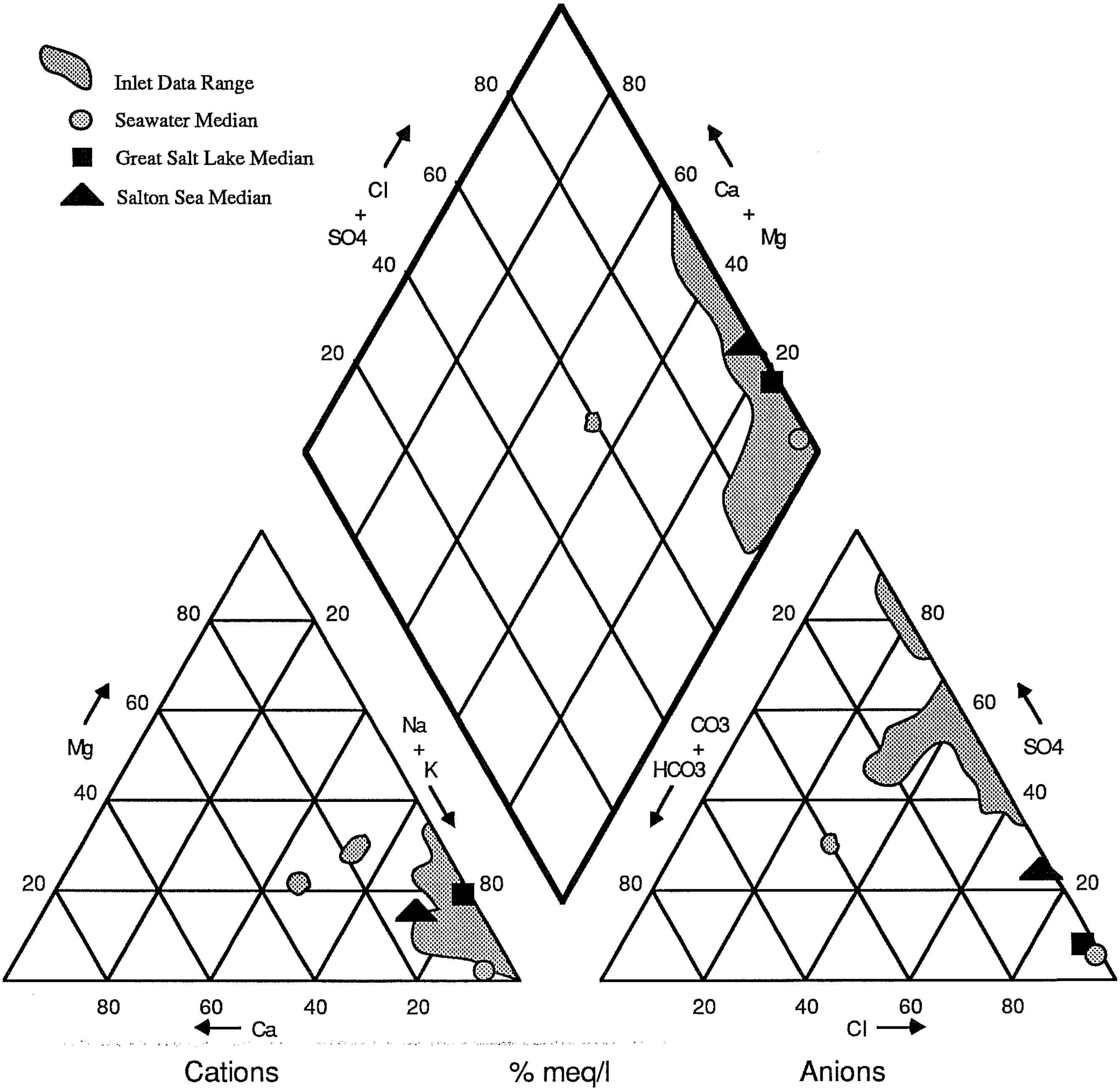


Table 8. Concentration Ranges for Selected Constituents in Agricultural Subsurface Drainage Water Inlets and Evaporation Basins in the San Joaquin Valley, 1988 and 1989

| ELEMENT | INLETS Minimum | Median | Geometric Mean | Maximum | SEAWATER 1/ Mean |
|---|---|---|---|---|---|
| Na (mg/L) | 80 | 4,200 | 3,160 | 18,000 | 10,500 |
| SO4 (mg/L) | 60 | 5,950 | 4,500 | 34,000 | 2,700 |
| Cl (mg/L) | 110 | 1,900 | 1,700 | 15,000 | 19,000 |
| EC (umhos/cm) | 790 | 18,300 | 14,100 | 55,300 | ND |
| B (mg/L) | 0 | 10 | 9 | 63 | 4.5 |
| TDS (mg/L) | 450 | 13,500 | 10,400 | 57,000 | 31,000 |
| As (ug/L) | 3 | 44 | 38 | 1,400 | 3 |
| Mo (ug/L) | 4 | 640 | 550 | 6,600 | 10 |
| Se (ug/L) | 0.4 | 5 | 7 | 760 | 0.1 |
| U (ug/L) | 6 | 170 | 190 | 3,100 | 3 |
| V (ug/L) | 5 | 61 | 54 | 943 | 2 |
| Ra (pCi/L) ** | 0.0 | 0.5 | 0.6 | 3.0 | ND |

| ELEMENT | BASINS Minimum | Median | Geometric Mean | Maximum | SALT LAKES* Geometric Mean |
|---|---|---|---|---|---|
| Na (mg/L) | 170 | 9,650 | 9,720 | 130,000 | 4,550 |
| SO4 (mg/L) | 150 | 14,000 | 13,300 | 170,000 | 1,350 |
| Cl (mg/L) | 150 | 5,450 | 5,490 | 110,000 | 3,700 |
| EC (umhos/cm) | 1,350 | 35,900 | 33,300 | 157,000 | 17,300 |
| B (mg/L) | 1 | 25 | 27 | 700 | 18 |
| TDS (mg/L) | 800 | 31,000 | 29,000 | 395,000 | 14,000 |
| As (ug/L) | 3 | 100 | 70 | 14,000 | 280 |
| Mo (ug/L) | 6 | 1,500 | 1,300 | 44,100 | 54 |
| Se (ug/L) | 0.3 | 13 | 16 | 6,300 | 0.6 |
| U (ug/L) | 6 | 370 | 350 | 22,300 | 30 |
| V (ug/L) | 1 | 24 | 27 | 490 | 23 |
| Ra (pCi/L) ** | 0.1 | 0.4 | 0.5 | 2.0 | ND |

1/ Seawater from Hem, J.D., 1985. Study and Interpretation of the Chemical Characteristics of Natural Water.

*Values come from 13 saline lakes in the Western United States (Westcot et al., 1990)

** Variability in low level results indicates that the majority of the values are <1 pCi/L.

ND = no data

evapoconcentration in certain basin cells, especially those basins that are operated "in series". The geometric mean for all the basin cells was approximately 29,000 mg/L TDS in comparison to 10,400 mg/L TDS for the inlet samples to these basins. The geometric mean of 29,000 mg/L TDS for the basin samples is greater than twice the geometric mean for the selected natural salt lakes studied, 14,000 mg/L TDS (Westcot et al., 1990). The 1986 and 1987 geometric means for the basins and inlets were approximately 32,000 mg/L TDS and 15,300 mg/L TDS respectively (Westcot et al., 1988a).

Trace element concentrations in the basin cell and subcell samples varied widely. As found in the previous 1986 and 1987 samples, the trace element concentrations in the basin samples were higher than the levels found in the corresponding inflow samples. The only exception was vanadium which had lower concentrations in the ponded water as compared to the inlet water. Complete trace element data is presented in Appendix B.

Selenium concentrations in the basins ranged from <1 to 6,300 $\mu$g/L with a geometric mean of 16 $\mu$g/L, over twice the geometric mean for the inlets (7 $\mu$g/L), and considerably higher than the geometric mean for the natural salt lakes studied (0.6 $\mu$g/L) (Westcot et al., 1990). The distribution of high and low values in the basins was directly related to selenium concentrations found in the basin inlets. The overall ranges of selenium do not appear to have changed between 1985 and 1989 (Figure 11). As in 1986 and 1987, only three basins, which accounted for 15 percent of the total surface acreage, had selenium concentrations greater than 100 $\mu$g/L (Westcot et al., 1988a). Similar to 1986 and 1987, for the remaining 19 operating basins which total 85 percent of the surface acreage, 45 percent of the acreage had water concentrations between 10 and 25 $\mu$g/L selenium and 30 percent had concentrations less than 10 $\mu$g/L selenium.

Arsenic concentrations in water samples collected from the evaporation basin cells varied widely with a range of 3 to 14,000 $\mu$g/L and a geometric mean of 70 $\mu$g/L, one-quarter of the geometric mean found in the natural salt lakes studied (280 $\mu$g/L) (Westcot et al., 1990). Unlike the inlets, the concentration distributions do not appear to have changed appreciably between 1985 and 1989. As seen in 1986 and 1987 basin samples, approximately 90 percent of the acreage had water concentrations of 500 $\mu$g/L arsenic or less (Westcot et al., 1988a). However, between 1985 and 1989, the data collected show an increase of approximately 10 percent in the percentage of acreage with arsenic concentrations greater than 500 $\mu$g/L (Figure 12). The values have not been checked for statistical significance.

The trace element that occurred in the highest concentration in the basins and the inlets is boron. During 1988 and 1989 the concentration of boron in the basin samples ranged from 1.1 to 700 mg/L and had a geometric mean of 27 mg/L. The 27 mg/L is three times higher than the geometric mean for the inlets (9 mg/L), and 1.5 times greater than the geometric mean found in the salt lakes studied (18 mg/L) (Westcot et al., 1990). The difference in the mean boron concentration in the basins and the natural salt lakes is approximately the same as the difference in mean total dissolved solids concentrations. This indicates that boron likely follows the natural salt buildup found in a basin or a natural salt lake. However, other trace elements do not show this similarity, and the buildup in the basin is likely the result of the initial inflow concentration. Boron concentrations have also remained fairly consistent over time.

Figure 11. Frequency Distribution of Selenium in Evaporation Basins Used for the Disposal of Agricultural Subsurface Drainage Water.

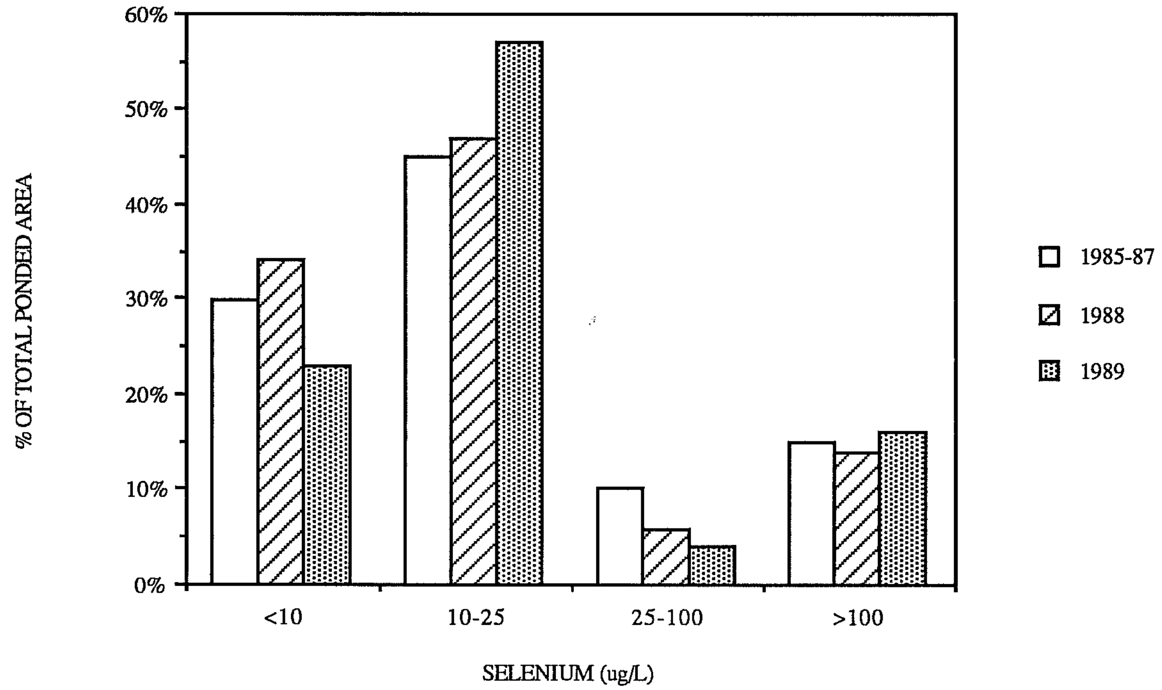
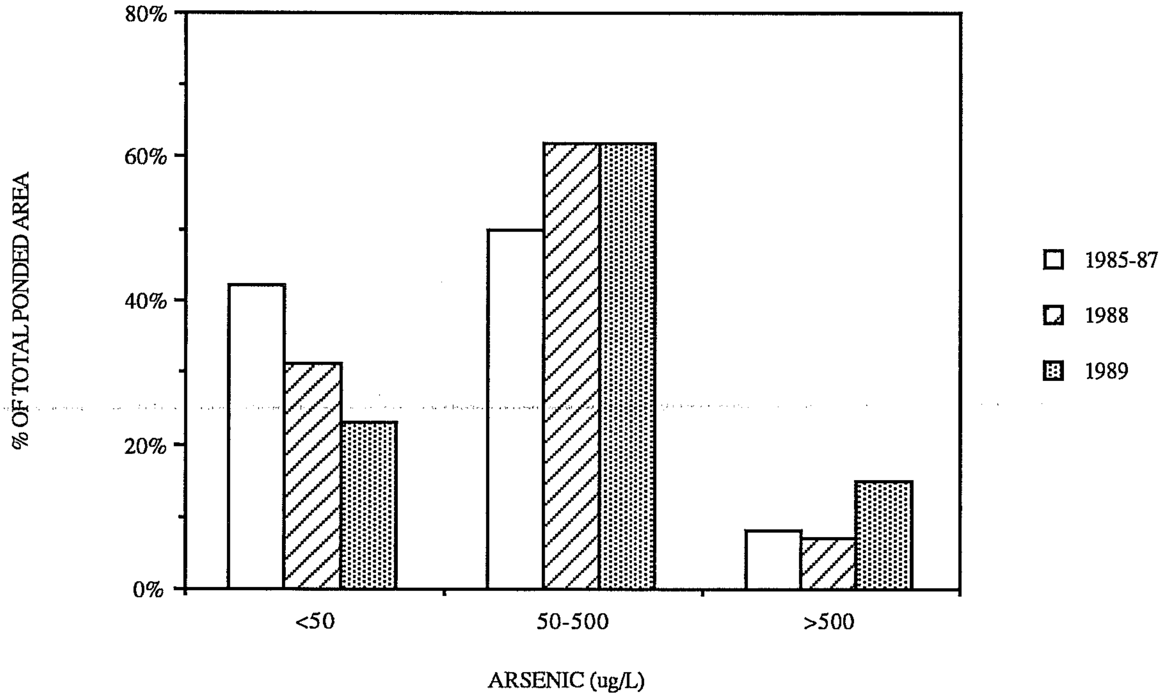



Figure 12. Frequency Distribution of Arsenic in Evaporation Basins Used for the Disposal of Agricultural Subsurface Drainage Water.



Approximately 50 percent of the acreage continued to show concentrations greater than 25 mg/L. Only 20 percent of the total acreage had a water concentration of less than 10 mg/L boron (Figure 13).

Molybdenum concentrations in the water of the basin cells ranged from 6 $\mu$g/L to 44,100 $\mu$g/L with a geometric mean of 1,300 $\mu$g/L. The geometric mean for the basin water molybdenum concentration is substantially higher than the corresponding mean for the natural salt lakes studied (54 $\mu$g/L) (Westcot el al., 1990). The percent of total ponded area falling within selected ranges of molybdenum concentrations has changed noticeably between 1985 and 1989 (Figure 14). During the 1985 through 1987 surveys, less than 40 percent of basin water acreage had reported concentrations of 200 to 2000 $\mu$g/L molybdenum (Westcot et al., 1988a). During 1988 and 1989, survey results indicated approximately 60 percent of the acreage had water molybdenum concentrations of 200 to 2000 $\mu$g/L. A corresponding 20 percent decrease in acreage with greater than 2000 $\mu$g/L concentrations also occurred between 1985 and 1989.

During 1988 and 1989, uranium concentrations in the basin water ranged from 6 $\mu$g/L to 22,300 $\mu$g/L with a geometric mean of 354 $\mu$g/L. Although the geometric mean is comparable to 1986 through 1987 (340 $\mu$g/L), the previous maximum concentration was 11,000 $\mu$g/L. The natural salt lakes studied showed a geometric mean of 30 $\mu$g/L (Westcot et al., 1990). The percent of total ponded acreage falling within specified concentration ranges remained consistent during the 1988 and 1989 surveys (Figure 15). However, a 40 percent acreage increase occurred between 1985 and 1988 for uranium concentrations greater than 400 $\mu$g/L. A corresponding decrease occurred for percent of acreage with less than 100 $\mu$g/L uranium. Percent of ponded acreage with midrange concentrations, 100 to 400 $\mu$g/L, remained fairly constant for all the surveys. The values have not been checked for statistical significance.

The vanadium concentrations in the basin water did not range as widely as concentrations in the inlet water. Values for the basins ranged from 1 mg/L to 490 $\mu$g/L with a geometric mean of 27 $\mu$g/L. The geometric mean for the inlets was 54 $\mu$g/L and for natural saline lakes, 23 $\mu$g/L. The frequency distribution between selected concentrations was relatively stable for both 1988 and 1989. Roughly 80 percent of the ponded area contained concentrations less than 50 $\mu$g/L. Less than 5 percent of the area contained concentrations exceeding 200 $\mu$g/L (Figure 16).

## GEOLOGY AND EVAPORATION BASIN WATER QUALITY

As noted in the previous evaporation basin data reports (Westcot el al., 1988a and b), subsurface drain systems that are discharged into the evaporation basins in the San Joaquin Valley drain soils that are derived primarily from three different geologic units (Figure 17). As described by Page (1986) and Croft (1972), these units are:

a.) Alluvial Fan: Continental alluvial deposits of Tertiary to Holocene age which include a heterogeneous mix of generally poorly sorted clay, silt, sand, and gravel commonly deposited in alluvial fans. In the present study area, these alluvial fans are located along the western flank and southern end of the San Joaquin Valley and originated in the Coast Range.

Figure 13. Frequency Distribution of Boron in Evaporation Basins Used for the Disposal of Agricultural Subsurface Drainage Water.

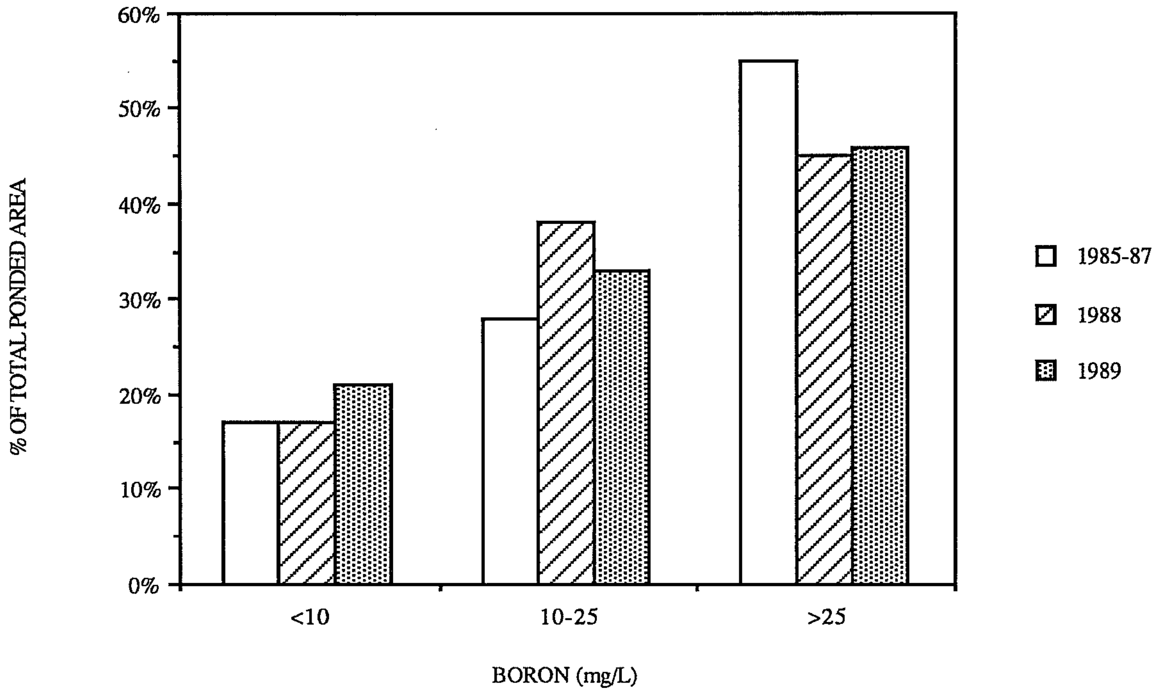



Figure 14. Frequency Distribution of Molybdenum in Evaporation Basins Used for the Disposal of Agricultural Subsurface Drainage Water.

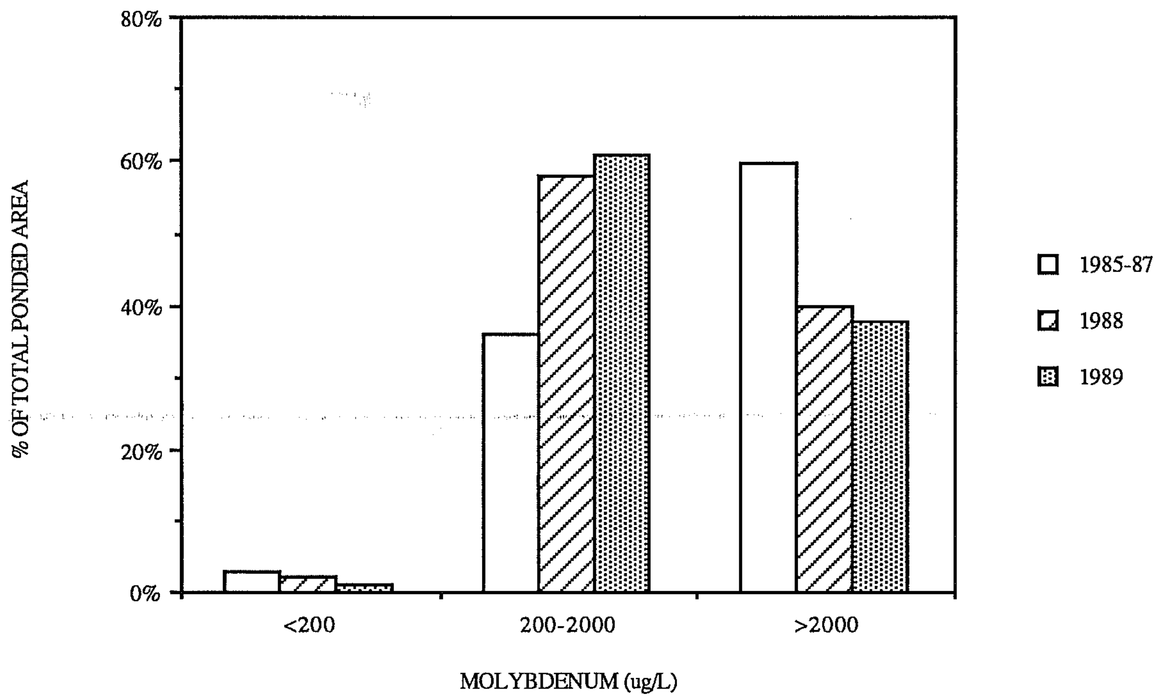


Figure 15. Frequency Distribution of Uranium in Evaporation Basins Used for the Disposal of Agricultural Subsurface Drainage Water.

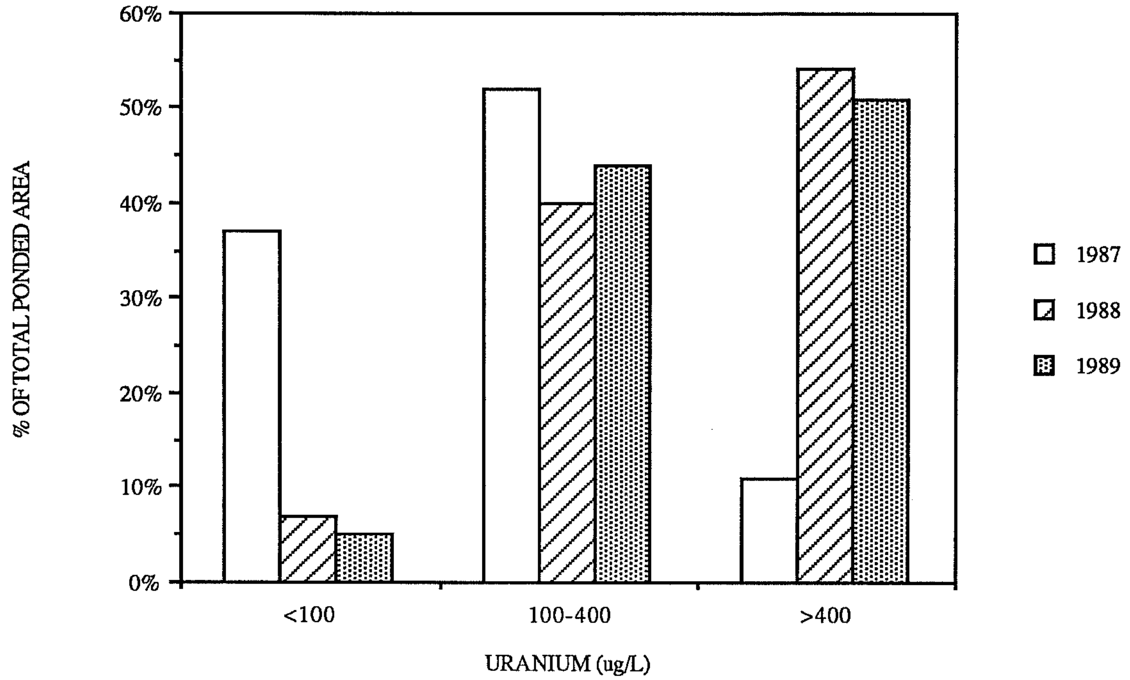
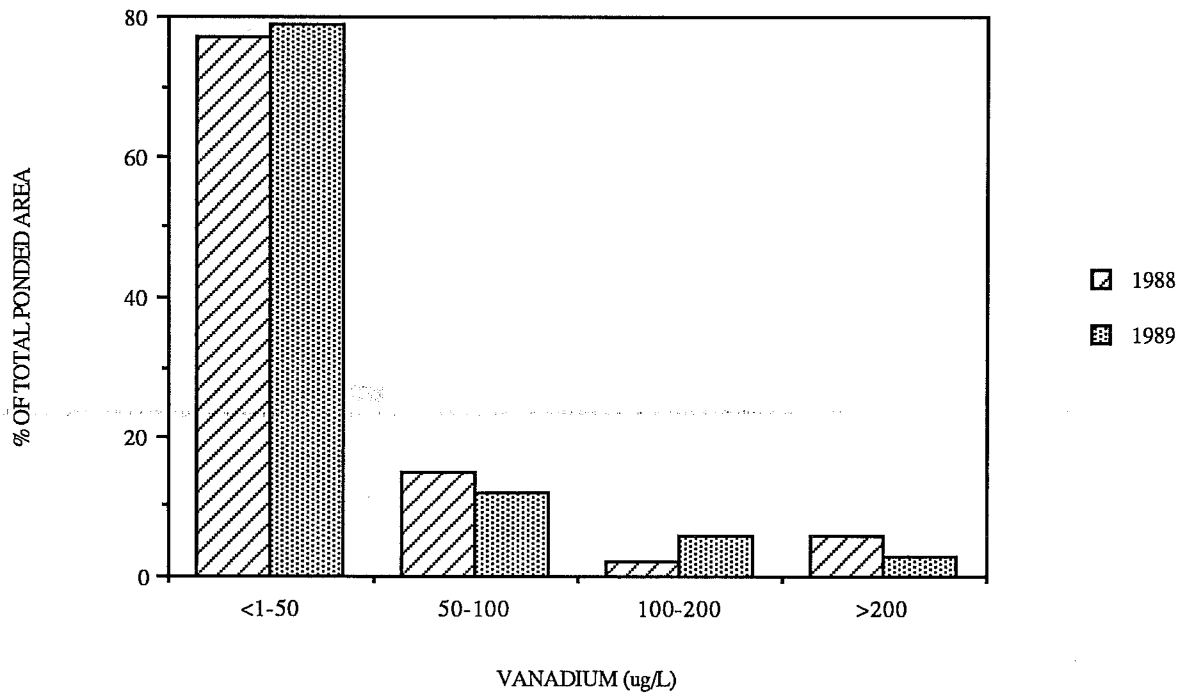



Figure 16. Frequency Distribution of Vanadium in Evaporation Basins Used for the Disposal of Agricultural Subsurface Drainage Water.



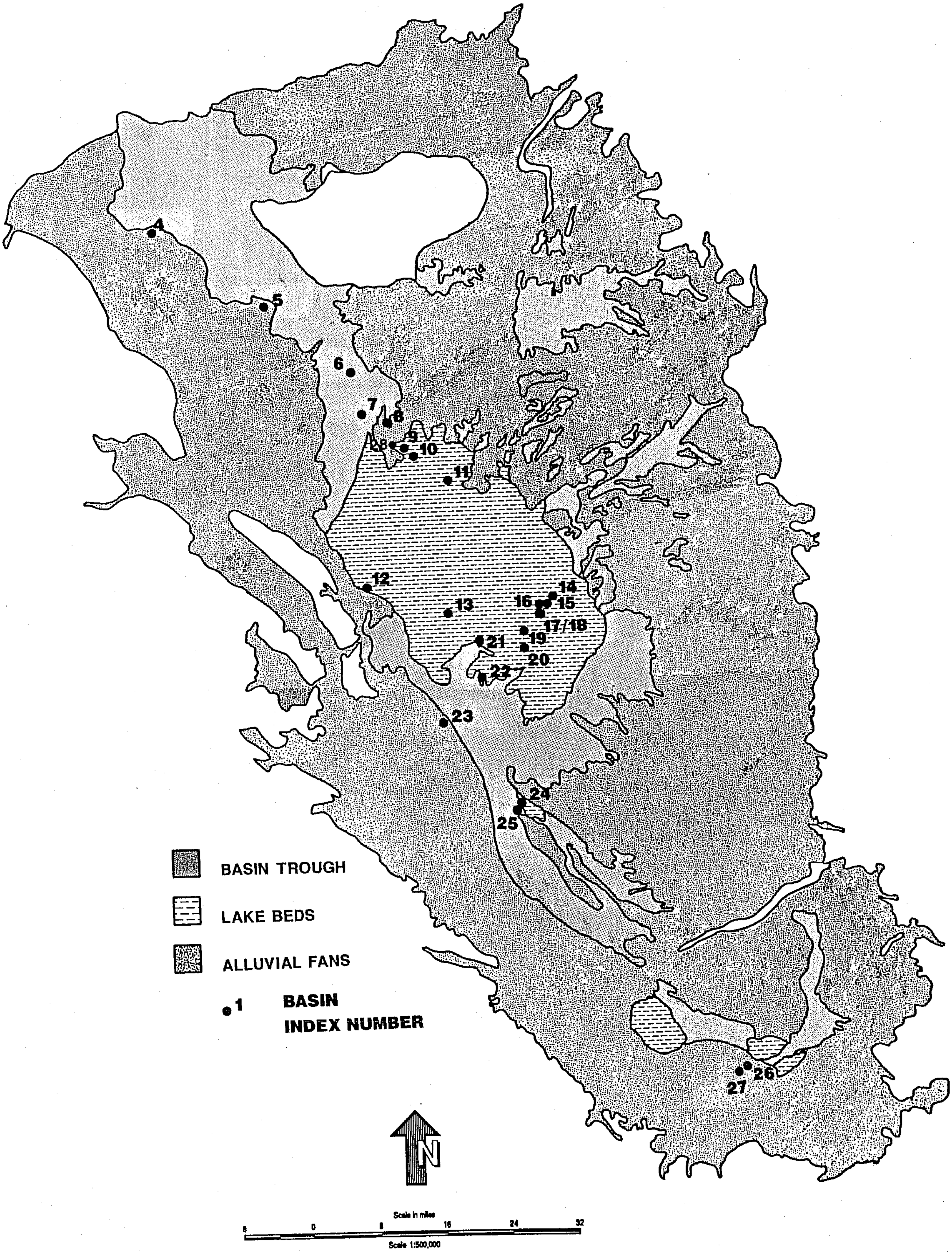



**Figure 17. Location of Agricultural Evaporation Basins in Geologic Settings of the Tulare Basin (Taken from Westcot et al., 1988a)**

b.) Basin Trough: Flood-basin deposits of Holocene age which crop out in low-lying areas in the basin (valley) trough. They result from flood waters entering low-lying basins and depositing mostly fine silt and clay and some fine sand derived from both the Coast Range and the Sierra Nevada. These deposits interfinger with and/or grade into the lacustrine and marsh deposits and the alluvial fan deposits.

c.) Lake Bed: Lacustrine and marsh deposits of Tertiary to Holocene age which underlie the ancient lake bed areas (now farmland) of the lower San Joaquin Valley. The lacustrine and marsh deposits consist chiefly of clay and silt and underlie the Tulare, Goose, Buena Vista and Kern Lake Beds. These deposits are of mixed Coast Range and Sierra Nevada origin.

Trace element concentrations varied widely depending on both the element involved as well as the geologic setting. For the 1988 and 1989 surveys, the ranges and geometric means of arsenic, selenium, molybdenum, uranium, and vanadium were calculated based on geologic setting (Table 9).

When comparing geometric means, total dissolved solids inflow concentrations did not show a marked difference based on geologic setting. Based on concentration ranges for individual samples, locations within the basin trough displayed the greatest variability. Total dissolved solids concentrations in the basin trough ranged from 450 mg/L to 49,000 mg/L, encompassing both the lowest and highest values reported for any of the inflows sites.

Boron inflow concentrations displayed a slightly different trend. The lowest reported boron concentration (0.3 mg/L) was located within the basin trough while the highest reported boron concentration (63 mg/L) and the highest geometric mean (23 mg/L) was located within the alluvial fan area, a known boron-rich area. The alluvial fan boron geometric mean of 23 mg/L compared to geometric means of 6.0 mg/L and 8.7 mg/L for the basin trough and lake bed, respectively.

Arsenic concentrations in the inflows appeared to have direct correlation with the geologic setting. The lowest arsenic concentrations occurred within the alluvial fan area. The highest concentration range and mean (27 µg/L to 1,400 µg/L and 250 µg/L, respectively) occurred in the lake bed samples. This follows the same trend as seen in the 1986 and 1987 samples (Westcot et al., 1988a).

Selenium displayed opposite characteristics to arsenic with extremely elevated concentrations (83 µg/L to 760 µg/L) associated with alluvial fan areas and much lower concentrations associated with basin trough and lake bed areas (geometric means of 2 µg/L and 11 µg/L, respectively) (Table 9). Selenium concentrations in inflow from the lake bed deposits showed greater variability than those of the basin trough, ranging from 4 µg/L to 62 µg/L as compared to 4 µg/L to 13 µg/L. Similar selenium concentration trends were found in the 1986 and 1987 data (Westcot el at., 1988a).

Molybdenum and uranium appeared to have relative inflow concentrations associated with each other as well as with geologic setting. For both elements, the lowest geometric means were found for basin trough areas (260 µg/L for molybdenum and 85 µg/L for uranium). The highest geometric means of 1300 µg/L and 450 µg/L for molybdenum and uranium, respectively, were in inflows from lake bed deposits. This trend for molybdenum and uranium is similar to the trend observed in an earlier analysis (Westcot et al., 1988a and b).

Table 9. Selected Trace Element and Total Dissolved Solids Concentrations for Inlet Flows to Evaporatio: Basins as Influenced by Geological Setting in the San Joaquin Valley of California, 1988 - 1989.

| CONSTITUENT | GEOLOGIC SETTING geometric mean (range) | | |
|---|---|---|---|
| | Alluvial Fan | Basin Trough | Lake Bed |
| TDS mg/L | 8,200 (1,600 - 29,000) | 9,700 (450 - 49,000) | 13,000 (3,400 - 49,000) |
| B mg/L | 23 (4.7 - 63) | 6 (0.3 - 36) | 8.7 (2.7 - 25) |
| As ug/L | 2 (ND - 4) | 11 (4 - 60) | 250 (27 - 1,400) |
| Se ug/L | 250 (83 - 760) | 2 (<1 - 13) | 11 (<1 - 62) |
| Mo ug/L | 500 (40 - 1,200) | 260 (4 - 1,300) | 1300 (160 - 6,600) |
| U ug/L | 140 (97 - 280) | 85 (6 - 280) | 450 (70 - 3,100) |
| V ug/L | 14 (5-24) | 28 (9-96) | 152 (14-943) |

Table 10. Selected Trace Element and Total Dissolved Solids Concentrations of Evaporation Basins as Influenced by Geoogic Setting in the San Joaquin Valley, California, 1988 - 1989.

| CONSTITUENT | GEOLOGIC SETTING geometric mean (range) | | |
|---|---|---|---|
| | Alluvial Fan | Basin Trough | Lake Bed |
| TDS mg/L | 43000 (5,800 - 400,000) | 36000 (800 - 280,000) | 22000 (1,900 - 360,000) |
| B mg/L | 74 (7.5 - 700) | 29.6 (1.1 - 340) | 16 (2.4 - 630) |
| As ug/L | 12 (ND - 420) | 19 (4 - 130) | 220 (6 - 14,000) |
| Se ug/L | 320 (29 - 6,300) | 2 (<1 - 13) | 2 (<1 - 13) |
| Mo ug/L | 1600 (90 - 12,000) | 600 (6 - 2,200) | 1500 (160 - 44,000) |
| U ug/L | 410 (55 - 8,000) | 130 (6 - 580) | 440 (34 - 22,000) |
| V ug/L | 26 (3-112) | 18 (1-74) | 31 (2-490) |

All water values reported as total recoverable

Figure 18. Comparison of Molybdenum and Uranium in Inlet Water from Alluvial Fan Areas.

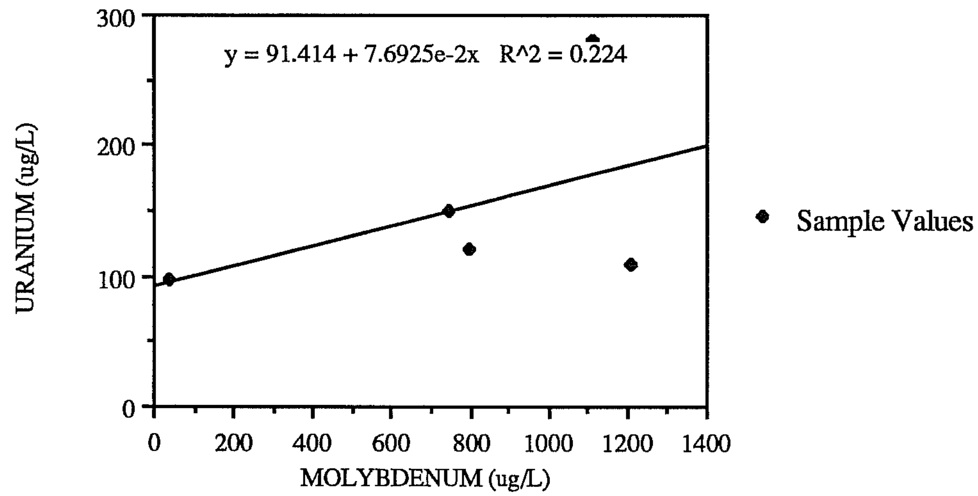



Figure 19. Comparison of Molybdenum and Uranium in Inlet Water from Basin Trough Areas

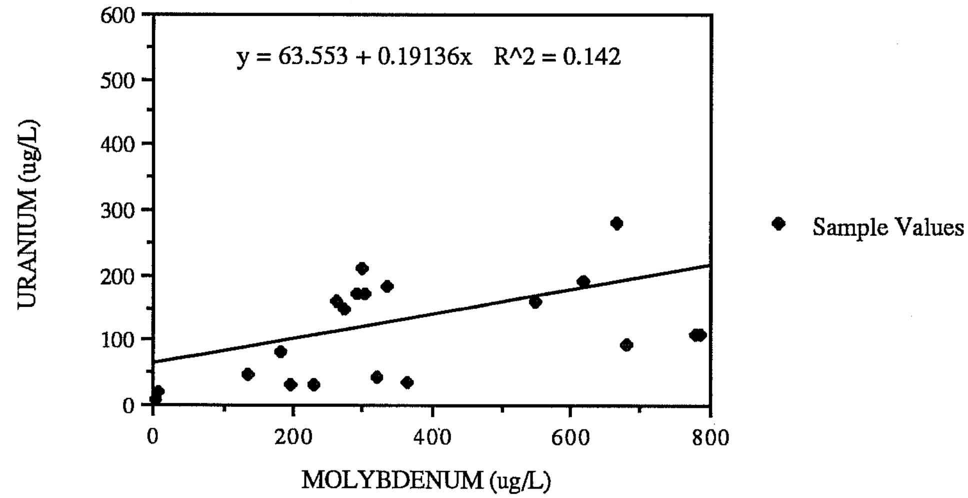



Figure 20. Comparison of Molybdenum and Uranium in Inlet Water from Lake Bed Areas.

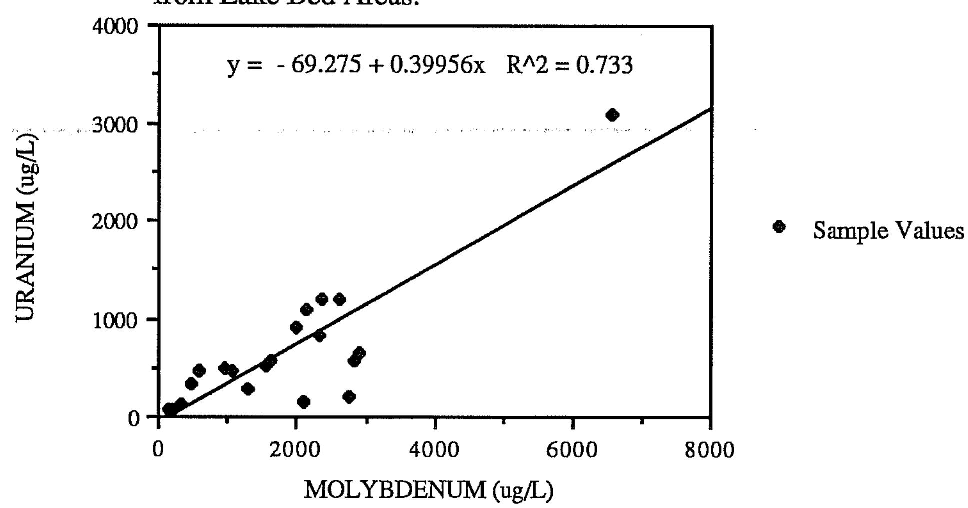


Figure 21. Comparison of Molybdenum and Uranium in Basin Water from Alluvial Fan Areas.

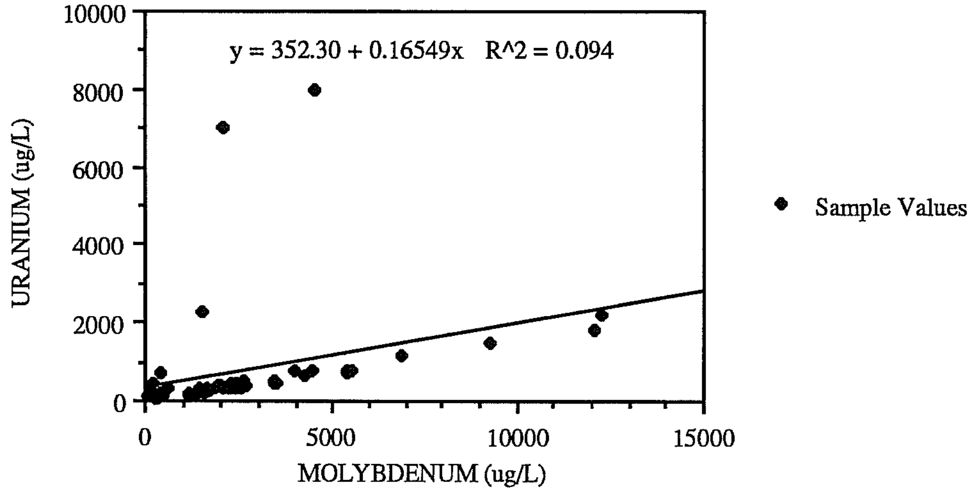



Figure 22. Comparison of Molybdenum and Uranium in Basin Water from Basin Trough Areas.

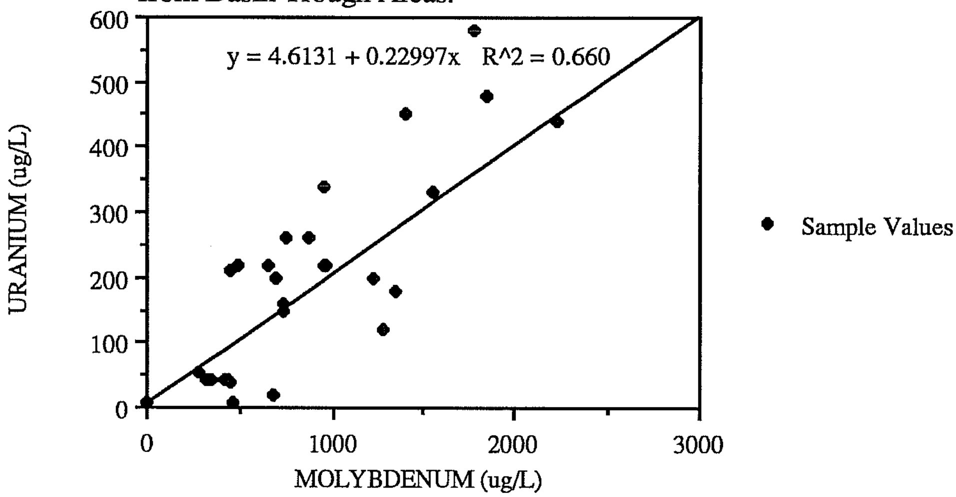
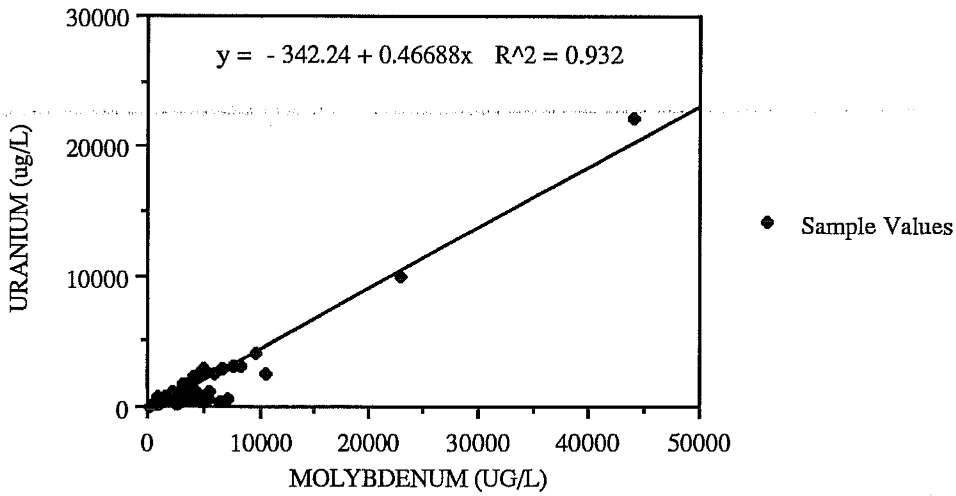
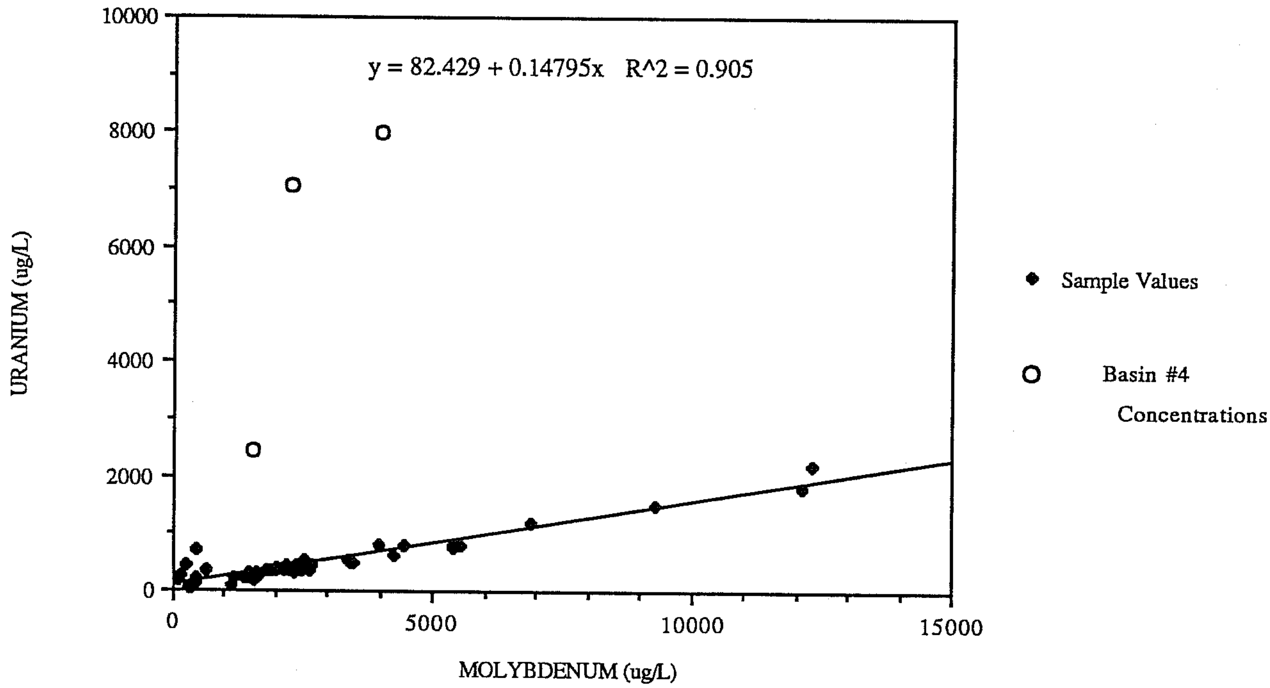



Figure 23. Comparison of Molybdenum and Uranium in Basin Water from Lake Bed Areas.



Figures 18 through 23 display molybdenum concentrations in relation to uranium concentrations for each of the geologic settings for both the inlets as well as the ponded water. Based an the $R^2$ factor for linear regression, no association between the two elements is apparent for either the alluvial fan or basin trough areas. For the lake bed inflows, however, correlations between concentrations reaches an $R^2$ of 0.733. The lake bed ponded water showed an $R^2$ of 0.932. Similarities in chemical transport and parent material may explain the lake bed association. Figure 24 details the relationship of molybdenum and uranium in alluvial fan basin water excluding basin 4, which accounts for the three highest concentrations. The $R^2$ of 0.905 may more accurately reflect processes of evapoconcentration of the two highly soluble elements.

Figure 24. Comparison of Molybdenum and Uranium in Evaporation Basin Water from Alluvial Fan Areas, Excluding Basin 4.




The highest concentrations of molybdenum and uranium were found in basins associated with the Alpaugh group in the southern half of the Tulare Lake bed. Elevated levels were also found in Basin 24 which is located in the Goose Lake bed area at the interface with basin trough deposits. Arsenic and boron also had elevated concentrations in the inflow to Basin 24.

Vanadium concentrations followed the same geologic trends as molybdenum and uranium, but at substantially lower concentrations. The highest geometric mean (32 µg/L) and highest value (490 µg/L) were found for lake bed settings. The lowest geometric mean (18 µg/L) was found for the basin trough area. Consistently elevated concentrations (> 200 µg/L) were detected in selected cells of basins 11, 19, 24, and 25 (TLDD North, 4-J Corporation, Carmel Ranch, and Lost Hills Ranch, respectively).

Concentrations within the basins appeared to follow the same trends for geologic settings as the inflows except for molybdenum and uranium (Table 10). Of all the elements, these latter two showed the greatest ability to concentrate in the evaporating water. Although ponded water in the basin trough areas still retained the lowest overall geometric means, the overall concentrations increased dramatically. Geometric mean concentrations between alluvial fan and lake bed areas have become comparable.

## Radium Analyses

The extremely high total recoverable uranium concentrations found in the evaporation basins indicated the possibility of elevated uranium by products, such as radium 226 (Ra 226). Radium, which has geochemical properties similar to those of barium, is especially hazardous because of its easy incorporation in bone leading to malignancies (Schroeder et al., 1988). Although no standards are available for aquatic life, the Federal and State Drinking Water Standards for radium are 5 picocuries per liter (pCi/L). One curie equals a unit of activity which in turn equals $2.22 \times 10^{12}$ decays per minute.

Levinson and Coetzee (1978) determined that if a system is in equilibrium, a rough guideline for Ra 226 would be 0.7 pCi/L radium per part per billion uranium. Using that assumption, based on reported uranium concentrations ranging from 330 to 22,300 ppb, Ra 226 should range from 230 to 15,600 pCi/L in the evaporation basins of the Tulare Lake Basin.

During 1989, 71 of the water samples containing the highest reported uranium concentrations were analyzed for Ra 226. The samples included 9 inlet samples, 58 ponded water samples, and 4 duplicates. Reported Ra 226 concentrations ranged from <0.1 to 3.1 pCi/L (Table 11). The values agreed with a similar finding by the U.S. Geological Survey for Westfarmers basins 1, 3A, 3B and 3C (Basin #23) which had Ra 226 values ranging from 0.2 to 0.5 pCi/L (Schroeder et al., 1988). The 1989 Regional Board findings indicated that inlet Ra 226 concentrations ranged from <0.1 to 3.1 pCi/L while basins ranged from <0.1 to 1.7 pCi/L. No discernible patterns were distinguished for samples collected in the three geological settings: alluvial fan, basin trough, or lake bed.

These findings indicate that agricultural evaporation basins are in gross disequilibrium with respect to uranium and radium water concentrations. Levinson and Coetzee (1978) report that disequilibrium is not unusual. Groundwater transported uranium can be significantly out of equilibrium if it is less than one million years old, due to radium's limited mobility. Factors limiting Ra 226 mobility include co-crystallization by substituting for barium, co-precipitation with iron and manganese, adsorption to organic material and clay, and biological adsorption. In aquatic environments, chlorides of radium are soluble whereas the carbonates and sulfates have very low solubilities (Levinson and Coetzee, 1978). The evaporation ponds are sulfate dominant as opposed to seawater, which is chloride dominant. Therefore, radium compounds would be expected to have low solubility in the ponds.

Table 11. 1989 Radiological Data for Evaporation Ponds.

| ID | Site Name | Cell | Geologic Setting | U (ug/L) | Ra226 (pCi/L) |
|---|---|---|---|---|---|
| 4 | Sumner Peck | 2 | Alluvial Fan | 8,300 | 0.8 |
| 4 | Sumner Peck | 3 | Alluvial Fan | 7,000 | 0.1 |
| 4 | Sumner Peck | 5 | Alluvial Fan | 2,300 | 0.3 |
| 4 | Sumner Peck | 6 | Alluvial Fan | 340 | 0.4 |
| 6 | Stone Land Co. | SE (a) | Basin Trough | 440 | 1.3 |
| 6 | Stone Land Co. | SE (b) | Basin Trough | 330 | <0.1 |
| 7 | Carlton Duty | Basin | Basin Trough | 580 | <0.1 |
| 10 | Barbizon | Basin | Basin Trough | 340 | <0.1 |
| 12 | Westlake #3 | 4 | Lake Bed | 330 | 0.4 |
| 12 | Westlake #3 | 5 | Lake Bed | 360 | <0.1 |
| 13 | J & W Farms | Basin | Lake Bed | 740 | 0.5 |
| 13 | J & W Farms | inlet | Lake Bed | 330 | <0.1 |
| 14 | Pryse Farms | inlet | Lake Bed | 560 | 0.7 |
| 14 | Pryse Farms | NE | Lake Bed | 700 | 0.1 |
| 15 | Bowman | NE-inlet | Lake Bed | 650 | <0.1 |
| 15 | Bowman | SE | Lake Bed | 620 | 0.8 |
| 16 | Morris | inlet | Lake Bed | 1,200 | 3.1 |
| 16 | Morris | SW | Lake Bed | 1,100 | 1.6 |
| 17 | Martin | inlet | Lake Bed | 900 | 0.5 |
| 17 | Martin | north | Lake Bed | 570 | <0.1 |
| 19 | 4-J Corp. | N - Inlet | Lake Bed | 470 | 0.3 |
| 19 | 4-J Corp. | NW corner | Lake Bed | 2,700 | 0.5 |
| 19 | 4-J Corp. | S - Inlet | Lake Bed | 3,100 | 0.3 |
| 21 | TLDD Hacienda | A2B (NE) | Lake Bed | 490 | 1.2 |
| 21 | TLDD Hacienda | A2b (SW) | Lake Bed | 420 | 0.1 |
| 21 | TLDD Hacienda | A3 (NW) | Lake Bed | 750 | 1.5 |
| 21 | TLDD Hacienda | A3 (SE) | Lake Bed | 780 | 0.6 |
| 21 | TLDD Hacienda | A4 (NE) | Lake Bed | 3,000 | 0.8 |
| 21 | TLDD Hacienda | A4 (NW) | Lake Bed | 3,000 | 0.2 |
| 21 | TLDD Hacienda | C2 (a) | Lake Bed | 590 | 0.1 |
| 21 | TLDD Hacienda | C2 (b) | Lake Bed | 570 | 0.2 |
| 21 | TLDD Hacienda | C3 | Lake Bed | 1,100 | 0.4 |
| 21 | TLDD Hacienda | C4 | Lake Bed | 3,000 | <0.1 |
| 21 | TLDD Hacienda | N. emergency basin | Lake Bed | 460 | 0.1 |
| 21 | TLDD Hacienda | S. emergency basin | Lake Bed | 610 | 0.3 |
| 22 | TLDD South | 1 | Lake Bed | 570 | 0.5 |
| 22 | TLDD South | 3 | Lake Bed | 340 | 0.6 |
| 22 | TLDD South | NW 4 | Lake Bed | 400 | 1.7 |
| 22 | TLDD South | SE 4 | Lake Bed | 380 | <0.1 |
| 22 | TLDD South | 5 | Lake Bed | 410 | 1.1 |
| 22 | TLDD South | 6 | Lake Bed | 510 | 0.1 |
| 22 | TLDD South | 7 | Lake Bed | 670 | 0.6 |
| 22 | TLDD South | 8 | Lake Bed | 1,000 | 1.5 |
| 22 | TLDD South | 9 | Lake Bed | 1,500 | 0.6 |

Table 11. 1989 Radiological Data for Evaporation Ponds (continued).

| ID | Site Name | Cell | Geologic Setting | U (ug/L) | Ra226 (pCi/L) |
|---|---|---|---|---|---|
| 22 | TLDD South | 10 | Lake Bed | 3,200 | 0.7 |
| 22 | TLDD South | inlet | Lake Bed | 500 | 1.1 |
| 22 | TLDD South | Salt Basin | Lake Bed | 520 | 0.7 |
| 23 | Lost Hills WD | 2 East | Alluvial Fan | 340 | 0.3 |
| 23 | Lost Hills WD | 3A NE | Alluvial Fan | 370 | 0.2 |
| 23 | Lost Hills WD | 3A SE | Alluvial Fan | 360 | 0.3 |
| 23 | Lost Hills WD | 3B North | Alluvial Fan | 370 | 0.3 |
| 23 | Lost Hills WD | 3C SE | Alluvial Fan | 530 | 1.1 |
| 23 | Lost Hills WD | 4 NE | Alluvial Fan | 740 | 0.2 |
| 23 | Lost Hills WD | 4NW | Alluvial Fan | 790 | 0.2 |
| 24 | Carmel Ranch | 1 SE | Lake Bed | 760 | 0.1 |
| 24 | Carmel Ranch | 2 NE | Lake Bed | 22,300 | 0.7 |
| 24 | Carmel Ranch | 3 S | Lake Bed | 850 | 0.3 |
| 24 | Carmel Ranch | 4 SE | Lake Bed | 870 | 0.2 |
| 24 | Carmel Ranch | 4A-Inlet | Lake Bed | 820 | 1.6 |
| 25 | Lost Hills Ranch | 3 N | Lake Bed | 590 | 0.5 |
| 26 | Sam Andrews' Sons | 1 | Alluvial Fan | 420 | 0.9 |
| 26 | Sam Andrews' Sons | 2A | Alluvial Fan | 855 | 0.5 |
| 26 | Sam Andrews' Sons | 2B | Alluvial Fan | 360 | 0.8 |
| 26 | Sam Andrews' Sons | 3A | Alluvial Fan | 790 | <0.1 |
| 26 | Sam Andrews' Sons | 3B | Alluvial Fan | 1,200 | 0.7 |
| 26 | Sam Andrews' Sons | 4A | Alluvial Fan | 1,500 | 0.4 |
| 26 | Sam Andrews' Sons | 4B | Alluvial Fan | 1,800 | 0.3 |

The presence of disequilibrium of uranium and Ra 226 in the ponds does not necessarily indicate a disequilibrium or excessive Ra 226 in another location. Evidence shows that the overall abundance of uranium is such that only a relatively small amount would need to be removed from a geologic deposit to produce the levels reported in the shallow groundwater and evaporation basins of the Tulare Lake Basin (Keil, personal communication).

In summary, of the 71 water samples expected to contain the highest Ra 226 concentrations, the maximum value detected was 3.1 pCi/L, which is well below the California and Federal drinking water standard of 5 piC/L. No standards for aquatic life are yet available.

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# APPENDIX A

APPENDIX A. Mineral Water Quality Data

| SITE NAME | CELL | DATE | EC umhos/cm | pH | Ca | Mg | Na | K | HC03 | SO4 | Cl | B | TDS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | (mg/L) | | | | | | | | |
| 1 SOUZA | CELL | 7/5/88 | 1350 | 7.9 | 54 | 47 | 165 | 14 | 28 | 150 | 160 | 1.1 | 800 |
| 1 SOUZA | NE-INLET | 7/5/88 | 1250 | 8.2 | 46 | 39 | 150 | 15 | 230 | 140 | 160 | 0.9 | 740 |
| 1 SOUZA | NORTH | 6/15/89 | 1710 | 8.4 | 60 | 66 | 215 | 11 | 300 | 205 | 150 | 1.9 | 1050 |
| 1 SOUZA | SE-INLET | 7/5/88 | 793 | 8.0 | 34 | 21 | 82 | 12 | 140 | 61 | 110 | 0.3 | 450 |
| 1 SOUZA | SE-INLET | 6/15/89 | 1360 | 8.3 | 48 | 50 | 150 | 11 | 250 | 170 | 130 | 1.4 | 830 |
| 1 SOUZA | SW-INLET | 7/5/88 | 1060 | 7.8 | 45 | 36 | 120 | 15 | 200 | 110 | 140 | 0.8 | 620 |
| 1 SOUZA | SW-INLET | 6/15/89 | 2910 | 8.3 | 64 | 120 | 420 | 1.8 | 440 | 480 | 280 | 3.9 | 1800 |
| 3 BRITZ SDP | INLET | 7/5/88 | 5440 | 8.0 | 490 | 170 | 640 | 8.2 | 280 | 2200 | 540 | 7.6 | 4500 |
| 3 BRITZ SDP | SOUTH | 7/5/88 | 6780 | 7.7 | 540 | 220 | 880 | 11 | 7.6 | 2900 | 720 | 10 | 5800 |
| 4 SUMNER PECK | 1 | 6/7/88 | 13700 | 7.4 | 540 | 160 | 3100 | 14 | 100 | 4500 | 1100 | 7.5 | 12000 |
| 4 SUMNER PECK | 1-SE INLET | 6/7/88 | 9590 | 8.0 | 560 | 130 | 2000 | 150 | 240 | 3400 | 770 | 4.7 | 8000 |
| 4 SUMNER PECK | 2 | 6/7/88 | 33000 | 7.4 | 540 | 540 | 9400 | 48 | 270 | 15000 | 3500 | 25 | 33000 |
| 4 SUMNER PECK | 2 | 6/6/89 | 134000 | 8.2 | 450 | 9500 | 78500 | 530 | 455 | 160000 | 63000 | 400 | 280000 |
| 4 SUMNER PECK | 3 | 6/7/88 | 23400 | 7.2 | 580 | 310 | 6000 | 30 | 130 | 8500 | 2200 | 15 | 21000 |
| 4 SUMNER PECK | 3 | 6/6/89 | 131000 | 8.0 | 83 | 16000 | 120000 | 920 | 740 | 170000 | 110000 | 700 | 395000 |
| 4 SUMNER PECK | 5 | 6/7/88 | 45900 | 8.2 | 550 | 840 | 14000 | 69 | 290 | 21000 | 5200 | 39 | 48000 |
| 4 SUMNER PECK | 5 | 6/6/89 | 102000 | 8.7 | 620 | 2700 | 49000 | 210 | 410 | 85000 | 23000 | 130 | 130000 |
| 4 SUMNER PECK | 6 | 6/7/88 | 18200 | 7.6 | 620 | 230 | 4200 | 20 | 88 | 6900 | 1700 | 10 | 16000 |
| 4 SUMNER PECK | 6 | 6/6/89 | 49000 | 9.2 | 640 | 820 | 15000 | 66 | 9 | 28000 | 7600 | 37 | 51000 |
| 5 BRITZ-DEAV 5PTS | NORTH | 6/7/88 | 20300 | 8.0 | 480 | 430 | 5200 | 6.2 | 230 | 8900 | 1000 | 37 | 20000 |
| 5 BRITZ-DEAV 5 PTS | NORTH | 6/6/89 | 22300 | 7.9 | 540 | 520 | 5800 | 6 | 220 | 13000 | 1300 | 46 | 21000 |
| 5 BRITZ-DEAV 5PTS | SOUTH | 6/7/88 | 19300 | 7.9 | 470 | 420 | 4700 | 6.4 | 200 | 8500 | 970 | 34 | 18000 |
| 5 BRITZ-DEAV 5 PTS | SOUTH | 6/6/89 | 21000 | 7.2 | 550 | 490 | 5400 | 9.5 | 180 | 12000 | 1300 | 43 | 19000 |
| 6 STONE LAND CO. | INLET SUMP 27 | 6/6/88 | 10000 | 7.9 | 350 | 380 | 2100 | 45 | 380 | 5000 | 480 | 10 | 8900 |
| 6 STONE LAND CO. | INLET SUMP 27 | 6/7/89 | 8660 | 8.3 | 230 | 270 | 1800 | 5.2 | 330 | 4000 | 340 | 9.8 | 7400 |
| 6 STONE LAND CO. | INLET SUMP 3 | 6/6/88 | 19800 | 8.0 | 430 | 450 | 5400 | 3.5 | 360 | 12000 | 910 | 35 | 19000 |
| 6 STONE LAND CO. | INLET SUMP 3 | 6/6/89 | 25600 | 7.9 | 430 | 760 | 6900 | 6 | 380 | 14000 | 2000 | 38 | 23000 |
| 6 STONE LAND CO. | INLET SUMP 34 | 6/7/89 | 19400 | 8.1 | 340 | 610 | 4800 | 10 | 420 | 9400 | 1000 | 22 | 18000 |
| 6 STONE LAND CO. | INLET SUMP 34F | 6/6/88 | 19500 | 8.0 | 400 | 680 | 4900 | 7.3 | 440 | 11000 | 1200 | 21 | 19000 |
| 6 STONE LAND CO. | NORTH (a) | 6/6/88 | 23100 | 8.0 | 440 | 880 | 5600 | 9.4 | 290 | 14000 | 1500 | 27 | 23000 |
| 6 STONE LAND CO. | NORTH (a) | 6/6/89 | 27350 | 9.0 | 465 | 1050 | 7150 | 9.2 | 64 | 16000 | 2250 | 38 | 28000 |
| 6 STONE LAND CO. | NORTH (b) | 6/6/88 | 23400 | 8.0 | 430 | 890 | 5900 | 9.6 | 270 | 12000 | 1500 | 29 | 22000 |
| 6 STONE LAND CO. | NORTH (b) | 6/6/89 | 30000 | 9.4 | 510 | 1200 | 7800 | 10 | <2 | 19000 | 2500 | 42 | 31000 |
| 6 STONE LAND CO. | SE (a) | 6/6/88 | 91400 | 8.0 | 610 | 5900 | 44000 | 50 | 900 | 84000 | 12000 | 160 | 160000 |
| 6 STONE LAND CO. | SE (a) | 6/6/89 | 111000 | 8.2 | 630 | 8400 | 77000 | 81 | 1400 | 160000 | 21000 | 340 | 240000 |
| 6 STONE LAND CO. | SE (b) | 6/6/88 | 91700 | 8.2 | 580 | 5900 | 44000 | 53 | 760 | 96000 | 12000 | 170 | 150000 |
| 6 STONE LAND CO. | SE (b) | 6/6/89 | 106000 | 8.2 | 670 | 7800 | 64000 | 7.4 | 1400 | 140000 | 20000 | 310 | 200000 |
| 6 STONE LAND CO. | SW (a) | 6/6/88 | 59100 | 7.6 | 660 | 2500 | 21000 | 25 | 460 | 41000 | 5900 | 100 | 74000 |
| 6 STONE LAND CO. | SW (a) | 6/6/89 | 80900 | 8.2 | 620 | 3700 | 40000 | 31 | 800 | 75000 | 9800 | 150 | 110000 |
| 6 STONE LAND CO. | SW (b) | 6/6/88 | 59000 | 7.3 | 580 | 2400 | 21000 | 31 | 440 | 41000 | 5900 | 81 | 76000 |
| 6 STONE LAND CO. | SW (b) | 6/6/89 | 80800 | 8.3 | 620 | 3700 | 41000 | 31 | 820 | 73000 | 12000 | 160 | 51000 |
| 6 STONE LAND CO. | SW INLET | 6/6/88 | 21800 | 7.9 | 420 | 510 | 5900 | 47 | 380 | 12000 | 1100 | 36 | 21000 |
| 7 CARLTON DUTY | AG INLET | 6/6/89 | 50900 | 7.8 | 480 | 2800 | 16000 | 12 | 530 | 34000 | 6300 | 38 | 57000 |
| 7 CARLTON DUTY | BASIN | 6/7/88 | 103000 | 8.0 | 600 | 13000 | 49000 | 100 | 1800 | 110000 | 28000 | 200 | 210000 |
| 7 CARLTON DUTY | BASIN | 6/6/89 | 113000 | 8.3 | 630 | 17000 | 73000 | 100 | 1900 | 160000 | 39000 | 240 | 280000 |
| 7 CARLTON DUTY | INCPTR INLET | 6/7/88 | 42350 | 7.9 | 440 | 2050 | 11500 | 12 | 505 | 26000 | 4350 | 31 | 48500 |
| 8 WESTLAKE-NORTH | 1-NE | 6/7/88 | 67600 | 7.4 | 520 | 2300 | 25000 | 29 | 360 | 48000 | 6400 | 46 | 91000 |
| 8 WESTLAKE NORTH | 1-NE | 6/6/89 | 55000 | 8.8 | 560 | 1600 | 17000 | 15 | 160 | 30000 | 4800 | 30 | 48000 |
| 8 WESTLAKE NORTH | 1-NW INLET | 6/6/89 | 40000 | 8.6 | 470 | 1300 | 14000 | 12 | 260 | 24000 | 3500 | 24 | 44000 |
| 8 WESTLAKE-NORTH | 1-S | 6/7/88 | 77500 | 7.6 | 560 | 2800 | 30000 | 35 | 370 | 65000 | 8100 | 57 | 110000 |
| 8 WESTLAKE-NORTH | 1-SW INLET | 6/7/88 | 23700 | 8.1 | 350 | 610 | 5700 | 8.8 | 480 | 12000 | 1800 | 9.6 | 23000 |
| 8 WESTLAKE NORTH | 1-SW INLET | 6/6/89 | 26800 | 7.9 | 400 | 810 | 7900 | 7.1 | 500 | 16000 | 2100 | 13 | 26000 |
| 8 WESTLAKE-NORTH | 2-INLET | 6/7/88 | 25200 | 8.2 | 380 | 690 | 6700 | 8.6 | 530 | 13000 | 2000 | 10 | 24000 |
| 8 WESTLAKE NORTH | 2-INLET | 6/6/89 | 26900 | 7.9 | 400 | 810 | 8000 | 6.9 | 470 | 14000 | 1900 | 13 | 26000 |
| 8 WESTLAKE-NORTH | 2-NE (d) | 6/7/88 | 40000 | 7.8 | 420 | 1200 | 12000 | 16 | 340 | 24000 | 3400 | 21 | 43000 |
| 8 WESTLAKE NORTH | 2-SE | 6/6/89 | 38100 | 8.1 | 600 | 1500 | 12000 | 15 | 260 | 24000 | 3100 | 25 | 42000 |
| 8 WESTLAKE-NORTH | 2-SE (c) | 6/7/88 | 39800 | 7.7 | 420 | 1200 | 11000 | 16 | 350 | 24000 | 3500 | 20 | 43000 |
| 8 WESTLAKE-NORTH | 2-SW (b) | 6/7/88 | 39800 | 7.7 | 430 | 1200 | 12000 | 17 | 360 | 23000 | 3500 | 19 | 43000 |
| 9 MEYERS RANCH | A | 6/6/88 | 13800 | 7.0 | 160 | 370 | 3100 | 15 | 200 | 6300 | 1100 | 5 | 12000 |
| 9 MEYERS RANCH | A | 6/6/89 | 19400 | 6.7 | 170 | 520 | 5600 | 22 | 130 | 9600 | 2200 | 7.1 | 16000 |
| 9 MEYERS RANCH | B | 6/6/88 | 15700 | 7.7 | 155 | 435 | 3800 | 17 | 160 | 6100 | 1600 | 5.5 | 13000 |
| 9 MEYERS RANCH | B | 6/6/89 | 25000 | 8.9 | 210 | 730 | 6700 | 22 | 160 | 12000 | 3100 | 10 | 22000 |
| 9 MEYERS RANCH | C | 6/6/88 | 18300 | 7.4 | 160 | 480 | 4400 | 20 | 160 | 7200 | 1900 | 6.7 | 16000 |
| 9 MEYERS RANCH | INLET | 6/6/88 | 8690 | 8.1 | 190 | 230 | 1800 | 10 | 380 | 3300 | 730 | 2.7 | 7000 |
| 9 MEYERS RANCH | INLET | 6/6/89 | 6640 | 7.8 | 140 | 160 | 1500 | 6.7 | 320 | 2400 | 560 | 2.6 | 4800 |

APPENDIX A. Mineral Water Quality Data

| SITE NAME | CELL | DATE | EC umhos/cm | pH | Ca | Mg | Na | K | HC03 | SO4 | Cl | B | TDS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | (mg/L) | | | | | | | | |
| 10 BARBIZON FARMS | E-INLET | 6/6/88 | 12100 | 8.3 | 120 | 170 | 2900 | 7.9 | 700 | 3400 | 1600 | 4.2 | 9200 |
| 10 BARBIZON FARMS | E-INLET | 6/6/89 | 11000 | 8.1 | 130 | 180 | 2450 | 7.4 | 700 | 3050 | 1400 | 4.9 | 7800 |
| 10 BARBIZON FARMS | EAST | 6/6/88 | 21100 | 8.0 | 120 | 340 | 5300 | 16 | 610 | 7100 | 3400 | 8.3 | 17000 |
| 10 BARBIZON FARMS | EAST | 6/6/89 | 53100 | 8.7 | 27 | 520 | 9700 | 33 | 630 | 12000 | 5600 | 17 | 20000 |
| 10 BARBIZON FARMS | MIDDLE | 6/6/88 | 32900 | 8.6 | 120 | 610 | 9300 | 21 | 190 | 14000 | 5600 | 14 | 31000 |
| 10 BARBIZON FARMS | W-INLET | 6/6/88 | 19100 | 8.1 | 280 | 400 | 4500 | 10 | 700 | 6200 | 2500 | 7.3 | 16000 |
| 10 BARBIZON FARMS | WEST | 6/6/88 | 27800 | 8.3 | 130 | 525 | 7100 | 23 | 295 | 9050 | 4350 | 11 | 25000 |
| 11 TLDD, NORTH | 1 | 6/6/88 | 5680 | 8.7 | 61 | 51 | 1300 | 6.2 | 590 | 1400 | 760 | 2.4 | 3800 |
| 11 TLDD, NORTH | 1 | 6/6/89 | 5220 | 8.8 | 62 | 49 | 1300 | 3.8 | 560 | 1100 | 580 | 2.6 | 3400 |
| 11 TLDD, NORTH | 2A | 6/6/88 | 8760 | 8.6 | 12 | 100 | 2100 | 10 | 700 | 2400 | 1100 | 4.2 | 6200 |
| 11 TLDD, NORTH | 2A | 6/6/89 | 8000 | 9.1 | 12 | 77 | 1900 | 6.3 | 720 | 1900 | 980 | 4.1 | 5300 |
| 11 TLDD, NORTH | 2B | 6/6/88 | 5780 | 8.7 | 47 | 51 | 1300 | 6.2 | 590 | 1400 | 760 | 2.6 | 3800 |
| 11 TLDD, NORTH | 2B | 6/6/89 | 5860 | 8.9 | 37 | 53 | 1500 | 4.7 | 530 | 1300 | 680 | 3 | 3900 |
| 11 TLDD, NORTH | 3A | 6/6/88 | 6950 | 8.7 | 24 | 78 | 1600 | 8.6 | 580 | 1800 | 870 | 3.2 | 4800 |
| 11 TLDD, NORTH | 3A | 6/6/89 | 7400 | 9.2 | 20 | 70 | 1700 | 5.7 | 660 | 1800 | 920 | 3.7 | 4900 |
| 11 TLDD, NORTH | 3B | 6/6/88 | 5930 | 8.9 | 31 | 56 | 1300 | 7.9 | 560 | 1400 | 780 | 2.6 | 4000 |
| 11 TLDD, NORTH | 3B | 6/6/89 | 6130 | 9.1 | 23 | 56 | 1600 | 5.1 | 440 | 1500 | 750 | 3.2 | 4100 |
| 11 TLDD, NORTH | 4 | 6/6/88 | 8840 | 8.4 | 25 | 120 | 2000 | 11 | 680 | 2500 | 1100 | 4.1 | 6300 |
| 11 TLDD, NORTH | 4 | 6/6/89 | 9000 | 9.2 | 20 | 90 | 2100 | 6.9 | 690 | 2400 | 1200 | 4.4 | 6100 |
| 11 TLDD, NORTH | 5A | 6/6/88 | 10200 | 8.3 | 22 | 140 | 2400 | 13 | 700 | 2900 | 1300 | 4.4 | 7400 |
| 11 TLDD, NORTH | 5A | 6/6/89 | 10000 | 9.0 | 14 | 99 | 2500 | 9 | 810 | 2800 | 1300 | 5.3 | 7000 |
| 11 TLDD, NORTH | 5B | 6/6/88 | 11300 | 8.1 | 21 | 140 | 2600 | 17 | 780 | 3600 | 1600 | 5.1 | 8300 |
| 11 TLDD, NORTH | 5B | 6/6/89 | 12000 | 9.1 | 13 | 130 | 3600 | 14 | 700 | 3600 | 1500 | 6.6 | 8500 |
| 11 TLDD, NORTH | 6 | 6/6/88 | 13300 | 8.3 | 14 | 140 | 3300 | 17 | 850 | 4000 | 1900 | 5.9 | 9900 |
| 11 TLDD, NORTH | 6 | 6/6/89 | 14000 | 9.1 | 10 | 110 | 3800 | 13 | 1100 | 4000 | 1900 | 7.8 | 9700 |
| 11 TLDD, NORTH | 7 | 6/6/88 | 22100 | 8.6 | 19 | 240 | 5600 | 31 | 1300 | 7600 | 3800 | 11 | 18000 |
| 11 TLDD, NORTH | 7 | 6/6/89 | 29700 | 9.1 | 15 | 330 | 8400 | 41 | 1800 | 9300 | 4200 | 17 | 25000 |
| 11 TLDD, NORTH | INLET | 6/6/88 | 6780 | 8.5 | 87 | 110 | 1400 | 8.1 | 540 | 2000 | 760 | 2.8 | 4800 |
| 11 TLDD, NORTH | INLET | 6/6/89 | 5200 | 8.7 | 63 | 49 | 1200 | 4.4 | 640 | 1100 | 610 | 2.7 | 3400 |
| 12 WESTLAKE #3 | 1 | 6/7/88 | 22000 | 7.5 | 490 | 870 | 4900 | 77 | 130 | 8700 | 4000 | 8.5 | 20000 |
| 12 WESTLAKE #3 | 1 | 6/6/89 | 60100 | 8.1 | 700 | 3100 | 17000 | 45 | 360 | 27000 | 13000 | 35 | 37000 |
| 12 WESTLAKE #3 | 2 | 6/7/88 | 27800 | 7.5 | 500 | 1100 | 6400 | 83 | 190 | 11000 | 5200 | 12 | 26000 |
| 12 WESTLAKE #3 | 2 | 6/6/89 | 37200 | 7.8 | 730 | 1600 | 9900 | 140 | 200 | 15000 | 7000 | 19 | 36000 |
| 12 WESTLAKE #3 | 3 | 6/7/88 | 24900 | 7.6 | 450 | 1000 | 5600 | 73 | 160 | 9200 | 4700 | 10 | 22000 |
| 12 WESTLAKE #3 | 3-INLET | 6/6/89 | 19900 | 7.5 | 460 | 860 | 4200 | 79 | 220 | 8300 | 4200 | 9 | 16000 |
| 12 WESTLAKE #3 | 4 | 6/7/88 | 80500 | 7.7 | 610 | 4000 | 27000 | 280 | 560 | 39000 | 21000 | 52 | 98000 |
| 12 WESTLAKE #3 | 4 | 6/6/89 | 81000 | 7.7 | 630 | 4000 | 27000 | 310 | 480 | 38000 | 20000 | 56 | 55000 |
| 12 WESTLAKE #3 | 5 | 6/7/88 | 56700 | 7.3 | 570 | 2600 | 17000 | 200 | 380 | 25000 | 12000 | 33 | 58000 |
| 12 WESTLAKE #3 | 5 | 6/6/89 | 79600 | 7.5 | 630 | 4100 | 27000 | 340 | 450 | 38000 | 20000 | 52 | 55000 |
| 12 WESTLAKE #3 | 6 | 6/7/88 | 33900 | 7.8 | 570 | 1100 | 8500 | 90 | 240 | 12500 | 7600 | 16 | 31000 |
| 12 WESTLAKE #3 | 6 | 6/6/89 | 72850 | 7.5 | 610 | 2950 | 23000 | 240 | 360 | 31000 | 17500 | 45 | 37000 |
| 13 J & W FARMS | CELL | 6/7/89 | 10300 | 8.2 | 310 | 180 | 2000 | 17 | 390 | 3200 | 1500 | 4.6 | 7500 |
| 13 J & W FARMS | INLET | 6/7/89 | 8910 | 8.3 | 230 | 160 | 1800 | 18 | 320 | 2800 | 1100 | 4.7 | 6400 |
| 14 PRYSE FARMS | 1 EAST | 6/7/88 | 52600 | 7.7 | 180 | 1100 | 15000 | 50 | 490 | 18000 | 14000 | 19 | 48000 |
| 14 PRYSE FARMS | 1 EAST | 6/7/89 | 57300 | 7.7 | 220 | 1200 | 16000 | 5.5 | 790 | 18000 | 14000 | 24 | 59000 |
| 14 PRYSE FARMS | 1 WEST | 6/7/88 | 52200 | 7.6 | 180 | 1000 | 14000 | 50 | 510 | 18000 | 14000 | 19 | 47000 |
| 14 PRYSE FARMS | 2 | 6/7/88 | 83700 | 7.4 | 310 | 1900 | 30000 | 92 | 510 | 34000 | 24000 | 36 | 86000 |
| 14 PRYSE FARMS | INLET | 6/7/88 | 30300 | 8.2 | 320 | 540 | 7300 | 25 | 830 | 9600 | 7100 | 8.9 | 25000 |
| 14 PRYSE FARMS | INLET | 6/7/89 | 29200 | 8.0 | 310 | 520 | 6900 | 21 | 950 | 8400 | 6300 | 11 | 23000 |
| 15 BOWMAN | A | 6/7/88 | 57400 | 8.1 | 830 | 1500 | 15000 | 49 | 180 | 18000 | 17000 | 14 | 52000 |
| 15 BOWMAN FARMS | A | 6/7/89 | 36100 | 8.9 | 570 | 860 | 8200 | 30 | 98 | 9200 | 9800 | 10 | 29000 |
| 15 BOWMAN | B | 6/7/88 | 77800 | 8.9 | 620 | 2200 | 23000 | 75 | 75 | 25000 | 24000 | 24 | 74000 |
| 15 BOWMAN FARMS | DISCHARGE | 6/7/89 | 15300 | 8.1 | 140 | 290 | 3200 | 8.4 | 460 | 4100 | 3100 | 4.9 | 10000 |
| 15 BOWMAN FARMS | NE-INLET | 6/7/89 | 47300 | 7.9 | 550 | 1100 | 12000 | 34 | 600 | 14000 | 13000 | 13 | 39000 |
| 15 BOWMAN | NW-INLET | 6/7/88 | 53200 | 8.0 | 550 | 1300 | 14000 | 47 | 580 | 16000 | 15000 | 14 | 49000 |
| 16 MORRIS FARM | CELL | 6/7/88 | 45100 | 8.6 | 610 | 840 | 12000 | 60 | 120 | 14000 | 12000 | 18 | 42000 |
| 16 MORRIS FARMS | CELL | 6/7/89 | 48200 | 7.6 | 550 | 920 | 12000 | 65 | 400 | 15000 | 12000 | 23 | 43000 |
| 16 MORRIS FARM | INLET | 6/7/88 | 21800 | 7.9 | 390 | 360 | 5000 | 25 | 730 | 6500 | 5000 | 8.6 | 17000 |
| 16 MORRIS FARMS | INLET | 6/7/89 | 22900 | 8.0 | 440 | 400 | 4900 | 23 | 760 | 5900 | 4900 | 9.9 | 17000 |
| 17 MARTIN FARMS | CELL | 6/7/88 | 36100 | 8.5 | 370 | 560 | 10000 | 40 | 180 | 15000 | 7600 | 19 | 32000 |
| 17 MARTIN FARMS | CELL | 6/7/89 | 56700 | 9.4 | 630 | 920 | 16000 | 67 | 7 | 26000 | 12000 | 37 | 43000 |
| 17 MARTIN FARMS | INLET | 6/7/88 | 20300 | 8.1 | 360 | 330 | 4900 | 21 | 610 | 6500 | 3500 | 9.1 | 18000 |
| 17 MARTIN FARMS | INLET | 6/7/89 | 16000 | 8.1 | 280 | 240 | 3800 | 16 | 550 | 4100 | 2300 | 8.4 | 12000 |
| 19 4-J CORP | CELL | 6/7/88 | 56400 | 9.2 | 6.6 | 320 | 19000 | 145 | 2700 | 22000 | 11000 | 51 | 53500 |
| 19 4-J CORP | CELL | 6/7/89 | 72200 | 9.3 | 8 | 310 | 25000 | 150 | 6600 | 30000 | 14000 | 75 | 50000 |

| SITE NAME | CELL | DATE | EC umhos/cm | pH | Ca | Mg | Na | K (mg/L) | HC03 | SO4 | Cl | B | TDS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19 4-J CORP | N-INLET | 6/7/89 | 13100 | 8.6 | 27 | 50 | 3400 | 21 | 1300 | 3000 | 1700 | 14 | 9100 |
| 19 4-J CORP | S-INLET | 6/7/89 | 55300 | 8.1 | 430 | 960 | 18000 | 22 | 1200 | 22000 | 11000 | 25 | 18000 |
| 21 TLDD HACIENDA | A1 | 6/6/88 | 11600 | 8.0 | 63 | 210 | 2700 | 25 | 320 | 3400 | 1800 | 5 | 8400 |
| 21 TLDD HACIENDA | A1 SE CORNER | 6/7/89 | 14000 | 7.3 | 40 | 260 | 3700 | 18 | 260 | 4500 | 2300 | 7.2 | 11000 |
| 21 TLDD HACIENDA | A1 SW CORNER | 6/7/89 | 14000 | 7.4 | 36 | 260 | 3700 | 18 | 240 | 5000 | 2800 | 6.9 | 10000 |
| 21 TLDD HACIENDA | A2 (a) | 6/6/88 | 14700 | 7.8 | 44 | 250 | 3400 | 26 | 340 | 5000 | 2500 | 6.4 | 11000 |
| 21 TLDD HACIENDA | A2 (a) | 6/7/89 | 17000 | 7.3 | 34 | 310 | 4000 | 22 | 400 | 5000 | 2600 | 9.1 | 13000 |
| 21 TLDD HACIENDA | A2 (b) | 6/7/89 | 17200 | 7.3 | 35 | 330 | 4300 | 22 | 400 | 5000 | 2700 | 9.5 | 12000 |
| 21 TLDD HACIENDA | A2 (c) | 6/6/88 | 16300 | 7.8 | 44 | 280 | 4000 | 29 | 310 | 5400 | 2700 | 7.3 | 13000 |
| 21 TLDD HACIENDA | A3 | 6/6/88 | 31200 | 7.7 | 87 | 630 | 8500 | 54 | 610 | 12000 | 6100 | 16 | 27000 |
| 21 TLDD HACIENDA | A3 NW CORNER | 6/7/89 | 31000 | 8.1 | 79 | 630 | 8300 | 49 | 720 | 11000 | 5300 | 18 | 27000 |
| 21 TLDD HACIENDA | A3 SE CORNER | 6/7/89 | 31100 | 8.1 | 80 | 340 | 8300 | 46 | 720 | 11000 | 5300 | 18 | 27000 |
| 21 TLDD HACIENDA | A4 | 6/6/88 | 97800 | 8.2 | 120 | 2900 | 38000 | 260 | 1200 | 55000 | 31000 | 72 | 130000 |
| 21 TLDD HACIENDA | A4 NE CORNER | 6/7/89 | 105000 | 8.6 | 110 | 3200 | 47000 | 230 | 1200 | 71000 | 35000 | 85 | 140000 |
| 21 TLDD HACIENDA | A4 NW CORNER | 6/7/89 | 105000 | 8.6 | 110 | 3200 | 49000 | 230 | 1200 | 77000 | 30000 | 89 | 130000 |
| 21 TLDD HACIENDA | C1 | 6/6/88 | 14900 | 8.1 | 47 | 290 | 3400 | 28 | 330 | 5400 | 2700 | 6.9 | 11000 |
| 21 TLDD HACIENDA | C1 NW CORNER | 6/7/89 | 13000 | 7.3 | 24 | 210 | 3300 | 16 | 310 | 4000 | 2100 | 6.2 | 9300 |
| 21 TLDD HACIENDA | C1 SE CORNER | 6/7/89 | 13000 | 7.3 | 28 | 220 | 3300 | 15 | 330 | 4000 | 2000 | 6.4 | 9600 |
| 21 TLDD HACIENDA | C2 | 6/6/88 | 27200 | 7.7 | 51 | 540 | 7000 | 44 | 500 | 9900 | 5200 | 14 | 23000 |
| 21 TLDD HACIENDA | C2 (a) | 6/7/89 | 13000 | 8.2 | 30 | 480 | 6500 | 34 | 570 | 8800 | 3900 | 13 | 19000 |
| 21 TLDD HACIENDA | C2 (b) | 6/7/89 | 24300 | 7.4 | 31 | 45 | 6200 | 37 | 580 | 7400 | 3600 | 14 | 18000 |
| 21 TLDD HACIENDA | C3 | 6/6/88 | 39500 | 7.4 | 58 | 780 | 11000 | 69 | 730 | 17000 | 8400 | 22 | 36000 |
| 21 TLDD HACIENDA | C3 | 6/7/89 | 42400 | 7.6 | 51 | 870 | 12000 | 69 | 940 | 13000 | 6300 | 26 | 20000 |
| 21 TLDD HACIENDA | C4 | 6/6/88 | 74850 | 8.4 | 53 | 1800 | 25000 | 155 | 1100 | 30000 | 1500 | 43 | 85000 |
| 21 TLDD HACIENDA | C4 | 6/7/89 | 102000 | 8.4 | 86 | 2800 | 40000 | 240 | 2000 | 60000 | 28000 | 76 | 63000 |
| 21 TLDD HACIENDA | MARSH N CELL | 6/6/88 | 55800 | 9.6 | 130 | 1400 | 17000 | 110 | 30 | 23000 | 14000 | 36 | 55000 |
| 21 TLDD HACIENDA | MARSH N. CELL | 6/7/89 | 36700 | 9.4 | 150 | 590 | 9800 | 49 | 110 | 15000 | 7200 | 22 | 22000 |
| 21 TLDD HACIENDA | MARSH S CELL | 6/6/88 | 70800 | 9.3 | 180 | 1900 | 23000 | 140 | 84 | 31000 | 18000 | 48 | 73000 |
| 21 TLDD HACIENDA | MARSH S. CELL | 6/7/89 | 39000 | 9.4 | 150 | 670 | 11000 | 52 | 120 | 14000 | 6200 | 24 | 21000 |
| 22 TLDD, SOUTH | 1 N SIDE | 6/7/88 | 19300 | 7.7 | 71 | 340 | 4900 | 23 | 280 | 5600 | 3200 | 9.8 | 15000 |
| 22 TLDD, SOUTH | 1 SW SIDE | 6/7/88 | 17200 | 8.0 | 86 | 270 | 4000 | 21 | 390 | 4900 | 2600 | 8.7 | 13000 |
| 22 TLDD, SOUTH | 1 SW SIDE | 6/6/89 | 13700 | 7.9 | 53 | 240 | 3100 | 14 | 350 | 3700 | 2000 | 7.3 | 10000 |
| 22 TLDD, SOUTH | 2 | 6/7/88 | 22100 | 8.0 | 67 | 360 | 5500 | 25 | 260 | 7600 | 3900 | 12 | 18000 |
| 22 TLDD, SOUTH | 2 | 6/6/89 | 16400 | 7.8 | 35 | 280 | 4200 | 16 | 310 | 4300 | 2600 | 9.1 | 12000 |
| 22 TLDD, SOUTH | 3 | 6/7/88 | 25600 | 7.6 | 69 | 410 | 6400 | 32 | 330 | 8900 | 4700 | 14 | 21000 |
| 22 TLDD, SOUTH | 3 | 6/6/89 | 18300 | 7.6 | 53 | 310 | 4600 | 20 | 370 | 6400 | 3100 | 10 | 14000 |
| 22 TLDD, SOUTH | 4 | 6/7/88 | 33800 | 7.6 | 70 | 600 | 9100 | 44 | 440 | 12000 | 6400 | 20 | 29000 |
| 22 TLDD, SOUTH | 4 NW CORNER | 6/6/89 | 20300 | 7.6 | 65 | 350 | 5200 | 23 | 410 | 6600 | 3100 | 11 | 15000 |
| 22 TLDD, SOUTH | 4 SE CORNER | 6/6/89 | 20900 | 7.5 | 79 | 360 | 5700 | 24 | 470 | 7200 | 3500 | 12 | 16000 |
| 22 TLDD, SOUTH | 5 | 6/7/88 | 48050 | 7.4 | 79 | 920 | 14000 | 66 | 630 | 19000 | 9900 | 31 | 45000 |
| 22 TLDD, SOUTH | 5 | 6/6/89 | 21300 | 7.4 | 71 | 370 | 5900 | 25 | 450 | 7500 | 3600 | 13 | 16000 |
| 22 TLDD, SOUTH | 6 | 6/7/88 | 64100 | 7.5 | 87 | 1300 | 20000 | 100 | 820 | 25000 | 13000 | 41 | 66000 |
| 22 TLDD, SOUTH | 6 | 6/6/89 | 24500 | 7.6 | 79 | 420 | 7300 | 29 | 540 | 8400 | 3900 | 15 | 19000 |
| 22 TLDD, SOUTH | 7 | 6/7/88 | 42100 | 7.8 | 79 | 790 | 12000 | 59 | 580 | 17000 | 8600 | 25 | 38000 |
| 22 TLDD, SOUTH | 7 | 6/6/89 | 31200 | 7.6 | 86 | 570 | 9400 | 38 | 1000 | 11000 | 5000 | 20 | 27000 |
| 22 TLDD, SOUTH | 8 | 6/7/88 | 37700 | 7.9 | 99 | 700 | 11000 | 57 | 620 | 14000 | 7200 | 23 | 33000 |
| 22 TLDD, SOUTH | 8 | 6/6/89 | 67000 | 8.5 | 100 | 1400 | 21000 | 98 | 970 | 29000 | 14000 | 51 | 39000 |
| 22 TLDD, SOUTH | 9 | 6/7/88 | 57000 | 8.2 | 140 | 1200 | 17000 | 88 | 830 | 23000 | 12000 | 36 | 55000 |
| 22 TLDD, SOUTH | 9 | 6/6/89 | 45700 | 8.2 | 110 | 890 | 14000 | 59 | 780 | 18000 | 9600 | 32 | 41000 |
| 22 TLDD, SOUTH | 10 | 6/7/88 | 108000 | 8.1 | 135 | 3200 | 45000 | 265 | 1300 | 57000 | 33000 | 99 | 140000 |
| 22 TLDD, SOUTH | 10 | 6/6/89 | 109000 | 8.6 | 100 | 3200 | 45000 | 280 | 1200 | 56000 | 34000 | 120 | 130000 |
| 22 TLDD, SOUTH | INLET | 6/7/88 | 12100 | 8.3 | 160 | 190 | 2800 | 17 | 540 | 3300 | 1900 | 5.5 | 9000 |
| 22 TLDD, SOUTH | INLET | 6/6/89 | 10800 | 8.1 | 170 | 190 | 2500 | 13 | 480 | 3200 | 1400 | 5.4 | 7600 |
| 22 TLDD, SOUTH | PERIM DRAIN | 6/7/88 | 32900 | 8.0 | 320 | 480 | 9600 | 26 | 650 | 10000 | 6100 | 22 | 29000 |
| 22 TLDD, SOUTH | SALT BASIN | 6/7/88 | 33500 | 7.3 | 58 | 570 | 9000 | 48 | 540 | 12000 | 6300 | 20 | 28000 |
| 22 TLDD, SOUTH | SALT BASIN | 6/6/89 | 27600 | 8.5 | 46 | 500 | 6900 | 33 | 530 | 9500 | 4600 | 17 | 23000 |
| 23 LOST HILLS WD | 1 (a) | 6/7/88 | 36200 | 8.9 | 730 | 410 | 10000 | 9.2 | 18 | 12000 | 7700 | 63 | 31000 |
| 23 LOST HILLS WD | 1 (a) | 6/7/89 | 25800 | 8.9 | 680 | 280 | 6200 | 6.8 | 35 | 8100 | 4300 | 42 | 17000 |
| 23 LOST HILLS WD | 1 (c) | 6/7/88 | 35000 | 8.8 | 760 | 410 | 9500 | 9.4 | 64 | 12000 | 7300 | 61 | 31000 |
| 23 LOST HILLS WD | 1 (c) | 6/7/89 | 24200 | 7.2 | 660 | 270 | 5900 | 8 | 310 | 7000 | 3700 | 42 | 20000 |
| 23 LOST HILLS WD | 1-INLET | 6/7/88 | 18000 | 8.1 | 540 | 190 | 4200 | 3.8 | 180 | 6300 | 3200 | 29 | 14000 |
| 23 LOST HILLS WD | 1-INLET | 6/7/89 | 16100 | 8.0 | 530 | 160 | 3500 | 3.8 | 180 | 4700 | 2300 | 63 | 13000 |
| 23 LOST HILLS WD | 2 EAST | 6/7/89 | 65550 | 8.6 | 605 | 880 | 21000 | 26 | 205 | 18000 | 14500 | 115 | 42000 |
| 23 LOST HILLS WD | 2 WEST | 6/7/89 | 65700 | 8.5 | 580 | 810 | 20000 | 29 | 230 | 17000 | 22000 | 110 | 32000 |
| 23 LOST HILLS WD | 3A NORTH | 6/6/88 | 97900 | 8.7 | 630 | 1400 | 36000 | 35 | 240 | 32000 | 35000 | 170 | 100000 |

APPENDIX A. Mineral Water Quality Data

| SITE NAME | CELL | DATE | EC umhos/cm | pH | Ca (mg/L) | Mg | Na | K | HC03 | SO4 | Cl | B | TDS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23 LOST HILLS WD | 3A NORTH | 6/7/89 | 76000 | 8.5 | 540 | 940 | 24000 | 24 | 310 | 23000 | 19000 | 130 | 56000 |
| 23 LOST HILLS WD | 3A SOUTH | 6/6/88 | 96450 | 8.7 | 575 | 1300 | 31000 | 39 | 125 | 31500 | 29500 | 160 | 110000 |
| 23 LOST HILLS WD | 3A SOUTH | 6/7/89 | 76000 | 8.3 | 560 | 950 | 24000 | 25 | 460 | 22000 | 18000 | 130 | 42000 |
| 23 LOST HILLS WD | 3A-INLET | 6/7/89 | 30000 | 8.0 | 590 | 390 | 7500 | 5.1 | 210 | 8400 | 5700 | 49 | 1600 |
| 23 LOST HILLS WD | 3B NORTH | 6/7/88 | 69600 | 8.9 | 640 | 800 | 22000 | 24 | 60 | 21000 | 21000 | 98 | 68000 |
| 23 LOST HILLS WD | 3B SOUTH | 6/6/88 | 62800 | 8.4 | 760 | 700 | 19000 | 20 | 240 | 26000 | 19000 | 80 | 56000 |
| 23 LOST HILLS WD | 3B-INLET | 6/7/89 | 53000 | 7.9 | 600 | 490 | 14000 | 9.1 | 200 | 11000 | 15000 | 43 | 29000 |
| 23 LOST HILLS WD | 3B-NORTH | 6/7/89 | 67100 | 8.4 | 630 | 790 | 20000 | 23 | 250 | 18000 | 21000 | 92 | 42000 |
| 23 LOST HILLS WD | 3B-SOUTH | 6/7/89 | 64700 | 8.2 | 650 | 750 | 19000 | 21 | 310 | 16000 | 16000 | 86 | 38000 |
| 23 LOST HILLS WD | 3C | 6/6/88 | 47800 | 8.4 | 630 | 540 | 13000 | 20 | 190 | 16000 | 13000 | 73 | 43000 |
| 23 LOST HILLS WD | 3C | 6/7/89 | 106000 | 8.5 | 580 | 1400 | 38000 | 41 | 430 | 32000 | 31000 | 180 | 73000 |
| 23 LOST HILLS WD | 4 NE | 6/7/89 | 131000 | 8.5 | 540 | 2000 | 54000 | 74 | 520 | 52000 | 50000 | 270 | 10000 |
| 23 LOST HILLS WD | 4-NE | 6/6/88 | 73200 | 8.8 | 680 | 940 | 24000 | 29 | 140 | 25000 | 23000 | 110 | 69000 |
| 23 LOST HILLS WD | 4-NW | 6/6/88 | 73000 | 8.8 | 660 | 900 | 24000 | 29 | 170 | 26000 | 23000 | 110 | 71000 |
| 23 LOST HILLS WD | 4-NW | 6/7/89 | 131000 | 8.5 | 565 | 2000 | 54500 | 66 | 555 | 40000 | 38500 | 245 | 165000 |
| 23 LOST HILLS WD | B. PIT | 6/7/88 | 42600 | 8.3 | 680 | 470 | 11000 | 17 | 190 | 13000 | 11000 | 58 | 39000 |
| 23 LOST HILLS WD | BORROW PIT | 6/7/89 | 79400 | 8.1 | 700 | 970 | 23000 | 61 | 300 | 20000 | 17000 | 65 | 53000 |
| 24 CARMEL RANCH | 1 | 6/6/88 | 56200 | 9.2 | 71 | 150 | 18000 | 37 | 260 | 19000 | 14000 | 65 | 51000 |
| 24 CARMEL RANCH | 1 | 6/7/89 | 43300 | 9.5 | 56 | 130 | 13000 | 24 | 380 | 12000 | 8400 | 46 | 37000 |
| 24 CARMEL RANCH | 1-INLET | 6/7/89 | 13500 | 8.2 | 120 | 42 | 3300 | 11 | 510 | 3200 | 1800 | 10 | 9200 |
| 24 CARMEL RANCH | 2 | 6/6/88 | 147000 | 8.0 | 245 | 1200 | 62500 | 220 | 1500 | 55000 | 59000 | 325 | 205000 |
| 24 CARMEL RANCH | 2 | 6/7/89 | 157000 | 8.2 | 94 | 2000 | 130000 | 240 | 1100 | 150000 | 100000 | 630 | 360000 |
| 24 CARMEL RANCH | 3 | 6/6/88 | 30900 | 8.2 | 76 | 150 | 8700 | 9.6 | 410 | 8500 | 6100 | 30 | 24000 |
| 24 CARMEL RANCH | 3 | 6/7/89 | 41700 | 8.9 | 89 | 190 | 12000 | 9.9 | 240 | 12000 | 7600 | 44 | 37000 |
| 24 CARMEL RANCH | 4 | 6/6/88 | 21800 | 8.4 | 110 | 120 | 5600 | 8.2 | 380 | 5700 | 4000 | 20 | 17000 |
| 24 CARMEL RANCH | 4 | 6/7/89 | 25000 | 8.5 | 120 | 130 | 7200 | 6.8 | 330 | 6600 | 4200 | 26 | 19000 |
| 24 CARMEL RANCH | 4A-INLET | 6/7/89 | 18600 | 8.2 | 190 | 82 | 4800 | 5.2 | 570 | 6000 | 3800 | 19 | 13000 |
| 24 CARMEL RANCH | 5 | 6/6/88 | 108000 | 8.7 | 110 | 360 | 45000 | 100 | 810 | 48000 | 33000 | 130 | 130000 |
| 25 LOST HILLS RANCH | 1 | 6/6/88 | 19300 | 8.3 | 160 | 100 | 4700 | 19 | 440 | 4600 | 4000 | 10 | 13000 |
| 25 LOST HILLS RANCH | 1 | 6/7/89 | 18100 | 8.8 | 54 | 90 | 4400 | 9 | 240 | 4500 | 3600 | 10 | 12000 |
| 25 LOST HILLS RANCH | 1-INLET | 6/6/88 | 17400 | 8.3 | 170 | 92 | 4100 | 15 | 490 | 4000 | 3400 | 9 | 14000 |
| 25 LOST HILLS RANCH | 1-INLET | 6/7/89 | 15600 | 8.2 | 140 | 80 | 3700 | 12 | 480 | 3100 | 2600 | 8.8 | 11000 |
| 25 LOST HILLS RANCH | 2 | 6/6/88 | 28200 | 8.1 | 150 | 140 | 7400 | 28 | 420 | 7000 | 6300 | 16 | 21000 |
| 25 LOST HILLS RANCH | 2 | 6/7/89 | 35600 | 8.9 | 83 | 120 | 6600 | 18 | 240 | 6400 | 5000 | 16 | 1900 |
| 25 LOST HILLS RANCH | 3 | 6/7/89 | 39800 | 8.5 | 130 | 160 | 11000 | 36 | 400 | 10000 | 7400 | 27 | 33000 |
| 26 SAM ANDREWS' SONS | 1 | 6/6/88 | 25500 | 8.2 | 480 | 640 | 6600 | 30 | 360 | 12000 | 1800 | 37 | 25000 |
| 26 SAM ANDREWS' SONS | 1 | 6/7/89 | 29400 | 9.0 | 560 | 860 | 8800 | 29 | 120 | 18000 | 2800 | 54 | 29000 |
| 26 SAM ANDREWS' SONS | 2A | 6/6/88 | 29400 | 8.4 | 530 | 760 | 8000 | 36 | 240 | 18000 | 2000 | 45 | 32000 |
| 26 SAM ANDREWS' SONS | 2A | 6/7/89 | 49650 | 9.2 | 635 | 1650 | 17000 | 60 | <2 | 36500 | 5650 | 120 | 59500 |
| 26 SAM ANDREWS' SONS | 2B | 6/6/88 | 27100 | 8.8 | 470 | 680 | 7300 | 29 | 98 | 12000 | 2000 | 43 | 27000 |
| 26 SAM ANDREWS' SONS | 2B | 6/7/89 | 40100 | 9.2 | 600 | 1300 | 13000 | 46 | <2 | 24000 | 3600 | 90 | 45000 |
| 26 SAM ANDREWS' SONS | 3A | 6/6/88 | 33400 | 8.7 | 530 | 950 | 10000 | 45 | 150 | 20000 | 2700 | 54 | 35000 |
| 26 SAM ANDREWS' SONS | 3A | 6/7/89 | 44200 | 8.9 | 630 | 1400 | 15000 | 52 | 110 | 27000 | 3200 | 100 | 51000 |
| 26 SAM ANDREWS' SONS | 3B | 6/6/88 | 34200 | 8.9 | 580 | 910 | 9600 | 53 | 94 | 16000 | 2600 | 56 | 36000 |
| 26 SAM ANDREWS' SONS | 3B | 6/7/89 | 62300 | 8.7 | 680 | 2300 | 27000 | 89 | 280 | 64000 | 15000 | 150 | 87000 |
| 26 SAM ANDREWS' SONS | 4A | 6/6/88 | 51500 | 8.6 | 600 | 1600 | 17000 | 93 | 350 | 29000 | 4900 | 100 | 61000 |
| 26 SAM ANDREWS' SONS | 4A | 6/7/89 | 85700 | 8.7 | 1100 | 5000 | 53000 | 160 | 390 | 89000 | 16000 | 240 | 160000 |
| 26 SAM ANDREWS' SONS | 4B | 6/6/88 | 96400 | 8.4 | 630 | 4600 | 46000 | 260 | 870 | 100000 | 14000 | 290 | 160000 |
| 26 SAM ANDREWS' SONS | 4B | 6/7/89 | 86000 | 8.5 | 660 | 3600 | 37000 | 180 | 970 | 65000 | 15000 | 280 | 140000 |
| 26 SAM ANDREWS' SONS | SUMPS | 6/7/89 | 23000 | 7.9 | 560 | 660 | 6500 | 25 | 310 | 12000 | 1400 | 35 | 21000 |

# APPENDIX B

APPENDIX B. Trace Element Water Quality Data

| SITE NAME | CELL | DATE | As | Mo | Se | U | V |
|---|---|---|---|---|---|---|---|
| | | | (ug/L) | | | | |
| 1 SOUZA | CELL | 7/5/88 | ND | ND | ND | ND | ND |
| 1 SOUZA | NE-INLET | 7/5/88 | ND | ND | ND | ND | ND |
| 1 SOUZA | NORTH | 6/15/89 | 6 | 6 | 1.07 | 9 | 18 |
| 1 SOUZA | SE-INLET | 7/5/88 | ND | ND | ND | ND | ND |
| 1 SOUZA | SE-INLET | 6/15/89 | 6 | 4 | 1.07 | 6 | 18 |
| 1 SOUZA | SW-INLET | 7/5/88 | ND | ND | ND | ND | ND |
| 1 SOUZA | SW-INLET | 6/15/89 | 5 | 9 | 2.77 | 18 | 15 |
| 3 BRITZ SDP | INLET | 7/5/88 | ND | ND | ND | ND | ND |
| 3 BRITZ SDP | SOUTH | 7/5/88 | ND | ND | ND | ND | ND |
| 4 SUMNER PECK | 1 | 6/7/88 | <10 | 90 | 772 | 160 | 15 |
| 4 SUMNER PECK | 1-SE INLET | 6/7/88 | <5 | 40 | 757 | 97 | 9 |
| 4 SUMNER PECK | 2 | 6/7/88 | <20 | 235 | 1313 | 430 | 23 |
| 4 SUMNER PECK | 2 | 6/6/89 | 78 | 4515 | 3318 | 8000 | 35 |
| 4 SUMNER PECK | 3 | 6/7/88 | <10 | 152 | 685 | 260 | 16 |
| 4 SUMNER PECK | 3 | 6/6/89 | 420 | 2020 | 323 | 7000 | 28 |
| 4 SUMNER PECK | 5 | 6/7/88 | <20 | 422 | 2207 | 720 | 24 |
| 4 SUMNER PECK | 5 | 6/6/89 | 29 | 1525 | 6280 | 2300 | 61 |
| 4 SUMNER PECK | 6 | 6/7/88 | <10 | 122 | 794 | 200 | 14 |
| 4 SUMNER PECK | 6 | 6/6/89 | 11 | 620 | 2091 | 340 | 23 |
| 5 BRITZ-DEAV 5PTS | NORTH | 6/7/88 | <10 | 272 | 79 | 63 | 4 |
| 5 BRITZ-DEAV 5 PTS | NORTH | 6/6/89 | 8 | 318 | 54.7 | 69 | 4 |
| 5 BRITZ-DEAV 5PTS | SOUTH | 6/7/88 | <10 | 282 | 74 | 61 | 3 |
| 5 BRITZ-DEAV 5 PTS | SOUTH | 6/6/89 | 3 | 324 | 60 | 55 | 26 |
| 6 STONE LAND CO. | INLET SUMP 27 | 6/6/88 | 6 | 198 | 1.6 | 33 | 13 |
| 6 STONE LAND CO, | INLET SUMP 27 | 6/7/89 | 4 | 229 | 5.6 | 31 | 13 |
| 6 STONE LAND CO. | INLET SUMP 3 | 6/6/88 | <10 | 778 | 3.7 | 110 | 33 |
| 6 STONE LAND CO. | INLET SUMP 3 | 6/6/89 | 5 | 681 | 7.38 | 95 | 21 |
| 6 STONE LAND CO. | INLET SUMP 34 | 6/7/89 | 5 | 362 | 2.34 | 37 | 9 |
| 6 STONE LAND CO. | INLET SUMP 34F | 6/6/88 | 7 | 319 | 2.1 | 41 | 10 |
| 6 STONE LAND CO. | NORTH (a) | 6/6/88 | 5 | 320 | 1 | 41 | 7 |
| 6 STONE LAND CO. | NORTH (a) | 6/6/89 | 5 | 411 | 0.76 | 43 | 8 |
| 6 STONE LAND CO. | NORTH (b) | 6/6/88 | 10 | 334 | 1.1 | 41 | 8 |
| 6 STONE LAND CO. | NORTH (b) | 6/6/89 | 6 | 446 | 0.85 | 40 | 6 |
| 6 STONE LAND CO. | SE (a) | 6/6/88 | <40 | 962 | 2 | 220 | 52 |
| 6 STONE LAND CO. | SE (a) | 6/6/89 | 110 | 2230 | 5.88 | 440 | 24 |
| 6 STONE LAND CO. | SE (b) | 6/6/88 | <40 | 952 | 2.2 | 220 | 50 |
| 6 STONE LAND CO. | SE (b) | 6/6/89 | 110 | 1550 | 6.86 | 330 | 30 |
| 6 STONE LAND CO. | SW (a) | 6/6/88 | 4 | 735 | 4.8 | 150 | 19 |
| 6 STONE LAND CO. | SW (a) | 6/6/89 | 42 | 1350 | 3.86 | 180 | 17 |
| 6 STONE LAND CO. | SW (b) | 6/6/88 | 7 | 725 | 4.7 | 160 | 18 |
| 6 STONE LAND CO. | SW (b) | 6/6/89 | 43 | 1225 | 3.7 | 200 | 21 |
| 6 STONE LAND CO. | SW INLET | 6/6/88 | <10 | 785 | 4.3 | 110 | 31 |
| 7 CARLTON DUTY | AG INLET | 6/6/89 | 6 | 548 | 10.6 | 160 | 11 |
| 7 CARLTON DUTY | BASIN | 6/7/88 | <50 | 1285 | 13 | 120 | 24 |
| 7 CARLTON DUTY | BASIN | 6/6/89 | 54 | 1780 | 11.4 | 580 | 22 |
| 7 CARLTON DUTY | INCPTR INLET | 6/7/88 | <20 | 459 | 13 | 530 | 11 |
| 8 WESTLAKE-NORTH | 1-NE | 6/7/88 | 130 | 1408 | 1.5 | 450 | 55 |
| 8 WESTLAKE NORTH | 1-NE | 6/6/89 | 93 | 640 | 0.7 | 220 | 32 |
| 8 WESTLAKE NORTH | 1-NW INLET | 6/6/89 | 45 | 620 | 0.6 | 190 | 54 |
| 8 WESTLAKE-NORTH | 1-S | 6/7/88 | 120 | 1840 | 1.7 | 480 | 50 |
| 8 WESTLAKE-NORTH | 1-SW INLET | 6/7/88 | 44 | 272 | 1.1 | 150 | 69 |
| 8 WESTLAKE NORTH | 1-SW INLET | 6/6/89 | 34 | 302 | 0.48 | 170 | 54 |
| 8 WESTLAKE-NORTH | 2-INLET | 6/7/88 | 46 | 261 | 1 | 160 | 66 |
| 8 WESTLAKE NORTH | 2-INLET | 6/6/89 | 30 | 290 | 0.44 | 170 | 56 |
| 8 WESTLAKE-NORTH | 2-NE (d) | 6/7/88 | 70 | 447 | 1.1 | 210 | 41 |
| 8 WESTLAKE NORTH | 2-SE | 6/6/89 | 86 | 687 | 5.42 | 200 | 32 |
| 8 WESTLAKE-NORTH | 2-SE (c) | 6/7/88 | 73 | 447 | 1.2 | 210 | 43 |
| 8 WESTLAKE-NORTH | 2-SW (b) | 6/7/88 | 73 | 442 | 1.3 | 210 | 68 |
| 9 MEYERS RANCH | A | 6/6/88 | 13 | 272 | 0.5 | 54 | 8 |
| 9 MEYERS RANCH | A | 6/6/89 | 12 | 459 | 0.96 | 6 | <5 |
| 9 MEYERS RANCH | B | 6/6/88 | <10 | 349 | 0.3 | 43 | 4 |
| 9 MEYERS RANCH | B | 6/6/89 | 14 | 678 | 0.56 | 20 | 1 |

| SITE NAME | CELL | DATE | As | Mo | Se (ug/L) | U | V |
|---|---|---|---|---|---|---|---|
| 9 MEYERS RANCH | C | 6/6/88 | <10 | 432 | 0.3 | 43 | 5 |
| 9 MEYERS RANCH | INLET | 6/6/88 | <5 | 182 | 1 | 83 | 23 |
| 9 MEYERS RANCH | INLET | 6/6/89 | 14 | 134 | 0.76 | 45 | 22 |
| 10 BARBIZON FARMS | E-INLET | 6/6/88 | 35 | 300 | 1.4 | 210 | 95 |
| 10 BARBIZON FARMS | E-INLET | 6/6/89 | 60 | 334 | 1.71 | 185 | 96 |
| 10 BARBIZON FARMS | EAST | 6/6/88 | 40 | 484 | 1.5 | 220 | 64 |
| 10 BARBIZON FARMS | EAST | 6/6/89 | 69 | 954 | 1.97 | 340 | 74 |
| 10 BARBIZON FARMS | MIDDLE | 6/6/88 | <20 | 872 | 0.5 | 260 | 11 |
| 10 BARBIZON FARMS | W-INLET | 6/6/88 | 36 | 664 | 1.3 | 280 | 72 |
| 10 BARBIZON FARMS | WEST | 6/6/88 | <20 | 746 | 0.6 | 260 | 38 |
| 11 TLDD, NORTH | 1 | 6/6/88 | 160 | 173 | 1.9 | 63 | 213 |
| 11 TLDD, NORTH | 1 | 6/6/89 | 170 | 162 | 1.7 | 66 | 194 |
| 11 TLDD, NORTH | 2A | 6/6/88 | 150 | 262 | 1.7 | 83 | 37 |
| 11 TLDD, NORTH | 2A | 6/6/89 | 220 | 222 | 1.56 | 57 | 25 |
| 11 TLDD, NORTH | 2B | 6/6/88 | 165 | 176 | 1.9 | 61 | 215 |
| 11 TLDD, NORTH | 2B | 6/6/89 | 220 | 177 | 1.68 | 34 | 184 |
| 11 TLDD, NORTH | 3A | 6/6/88 | 140 | 189 | 2.1 | 66 | 134 |
| 11 TLDD, NORTH | 3A | 6/6/89 | 200 | 205 | 1.86 | 53 | 48 |
| 11 TLDD, NORTH | 3B | 6/6/88 | 160 | 182 | 1.7 | 60 | 271 |
| 11 TLDD, NORTH | 3B | 6/6/89 | 200 | 172 | 1.82 | 63 | 129 |
| 11 TLDD, NORTH | 4 | 6/6/88 | 140 | 242 | 2 | 79 | 54 |
| 11 TLDD, NORTH | 4 | 6/6/89 | 240 | 270 | 1.64 | 67 | 12 |
| 11 TLDD, NORTH | 5A | 6/6/88 | 160 | 288 | 1.7 | 73 | 22 |
| 11 TLDD, NORTH | 5A | 6/6/89 | 190 | 330 | 1.54 | 91 | 5 |
| 11 TLDD, NORTH | 5B | 6/6/88 | 180 | 293 | 1.7 | 78 | 37 |
| 11 TLDD, NORTH | 5B | 6/6/89 | 310 | 326 | 1.5 | 97 | 21 |
| 11 TLDD, NORTH | 6 | 6/6/88 | 180 | 427 | 1.9 | 110 | 10 |
| 11 TLDD, NORTH | 6 | 6/6/89 | 280 | 552 | 1.88 | 170 | 2 |
| 11 TLDD, NORTH | 7 | 6/6/88 | 400 | 582 | 1 | 200 | 6 |
| 11 TLDD, NORTH | 7 | 6/6/89 | 720 | 841 | 0.9 | 310 | 5 |
| 11 TLDD, NORTH | INLET | 6/6/88 | 180 | 209 | 2.6 | 79 | 154 |
| 11 TLDD, NORTH | INLET | 6/6/89 | 150 | 163 | 1.97 | 70 | 190 |
| 12 WESTLAKE #3 | 1 | 6/7/88 | 80 | 429 | 8.6 | 130 | 14 |
| 12 WESTLAKE #3 | 1 | 6/6/89 | 220 | 758 | 12.6 | 290 | 15 |
| 12 WESTLAKE #3 | 2 | 6/7/88 | 100 | 402 | 12 | 130 | 12 |
| 12 WESTLAKE #3 | 2 | 6/6/89 | 110 | 522 | 7.12 | 160 | 13 |
| 12 WESTLAKE #3 | 3 | 6/7/88 | 90 | 422 | 16 | 130 | 11 |
| 12 WESTLAKE #3 | 3-INLET | 6/6/89 | 120 | 338 | 6.51 | 130 | 14 |
| 12 WESTLAKE #3 | 4 | 6/7/88 | 230 | 678 | 13 | 290 | 15 |
| 12 WESTLAKE #3 | 4 | 6/6/89 | 160 | 810 | 8.86 | 330 | 25 |
| 12 WESTLAKE #3 | 5 | 6/7/88 | 160 | 502 | 5.4 | 160 | 8 |
| 12 WESTLAKE #3 | 5 | 6/6/89 | 250 | 787 | 10.8 | 360 | 25 |
| 12 WESTLAKE #3 | 6 | 6/7/88 | 37 | 557 | 5.4 | 130 | 8 |
| 12 WESTLAKE #3 | 6 | 6/6/89 | 170 | 805 | 6.38 | 180 | 8 |
| 13 J & W FARMS | CELL | 6/7/89 | 23 | 878 | 27.4 | 740 | 24 |
| 13 J & W FARMS | INLET | 6/7/89 | 27 | 473 | 10.2 | 330 | 30 |
| 14 PRYSE FARMS | 1 EAST | 6/7/88 | 550 | 2740 | 11 | 580 | 137 |
| 14 PRYSE FARMS | 1 EAST | 6/7/89 | 730 | 3035 | 17 | 700 | 126 |
| 14 PRYSE FARMS | 1 WEST | 6/7/88 | 540 | 2770 | 11 | 570 | 136 |
| 14 PRYSE FARMS | 2 | 6/7/88 | 1100 | 4325 | 9.4 | 1100 | 80 |
| 14 PRYSE FARMS | INLET | 6/7/88 | 320 | 1530 | 9.6 | 510 | 229 |
| 14 PRYSE FARMS | INLET | 6/7/89 | 420 | 1600 | 9.95 | 560 | 245 |
| 15 BOWMAN | A | 6/7/88 | <30 | 4280 | 13 | 600 | 9 |
| 15 BOWMAN FARMS | A | 6/7/89 | 58 | 2370 | 17.2 | 620 | 36 |
| 15 BOWMAN | B | 6/7/88 | <30 | 6465 | 33 | 400 | <20 |
| 15 BOWMAN FARMS | DISCHARGE | 6/7/89 | 190 | 845 | 2.45 | 140 | 232 |
| 15 BOWMAN FARMS | NE-INLET | 6/7/89 | 250 | 2885 | 19.4 | 650 | 161 |
| 15 BOWMAN | NW-INLET | 6/7/88 | 220 | 2835 | 13 | 570 | 172 |
| 16 MORRIS FARM | CELL | 6/7/88 | 30 | 3565 | 23 | 460 | 18 |
| 16 MORRIS FARMS | CELL | 6/7/89 | 150 | 3860 | 48.5 | 1100 | 47 |
| 16 MORRIS FARM | INLET | 6/7/88 | 240 | 2145 | 54 | 1100 | 194 |
| 16 MORRIS FARMS | INLET | 6/7/89 | 220 | 2340 | 62.4 | 1200 | 165 |

| SITE NAME | CELL | DATE | As | Mo | Se (ug/L) | U | V |
|---|---|---|---|---|---|---|---|
| 17 MARTIN FARMS | CELL | 6/7/88 | 100 | 4350 | 37 | 910 | 38 |
| 17 MARTIN FARMS | CELL | 6/7/89 | 36 | 5495 | 22 | 570 | 11 |
| 17 MARTIN FARMS | INLET | 6/7/88 | 250 | 2600 | 60 | 1200 | 166 |
| 17 MARTIN FARMS | INLET | 6/7/89 | 280 | 1995 | 38.1 | 900 | 155 |
| 19 4-J CORP | CELL | 6/7/88 | 3100 | 4080 | 50 | 2400 | 490 |
| 19 4-J CORP | CELL | 6/7/89 | 5100 | 5375 | 38 | 2700 | 469 |
| 19 4-J CORP | N-INLET | 6/7/89 | 1400 | 596 | 13.9 | 470 | 943 |
| 19 4-J CORP | S-INLET | 6/7/89 | 480 | 6575 | 43.3 | 3100 | 219 |
| 21 TLDD HACIENDA | A1 | 6/6/88 | 100 | 920 | 25 | 370 | 66 |
| 21 TLDD HACIENDA | A1 SE CORNER | 6/7/89 | 120 | 1210 | 15.8 | 250 | 15 |
| 21 TLDD HACIENDA | A1 SW CORNER | 6/7/89 | 110 | 1175 | 10.5 | 240 | 11 |
| 21 TLDD HACIENDA | A2 (a) | 6/6/88 | 88 | 1080 | 22 | 470 | 39 |
| 21 TLDD HACIENDA | A2 (a) | 6/7/89 | 170 | 1355 | 11.2 | 420 | 9 |
| 21 TLDD HACIENDA | A2 (b) | 6/7/89 | 170 | 1415 | 10.8 | 490 | 7 |
| 21 TLDD HACIENDA | A2 (c) | 6/6/88 | 100 | 1220 | 21 | 400 | 24 |
| 21 TLDD HACIENDA | A3 | 6/6/88 | 200 | 2065 | 13 | 810 | 14 |
| 21 TLDD HACIENDA | A3 NW CORNER | 6/7/89 | 260 | 2105 | 12.2 | 750 | 16 |
| 21 TLDD HACIENDA | A3 SE CORNER | 6/7/89 | 270 | 2130 | 12.8 | 780 | 17 |
| 21 TLDD HACIENDA | A4 | 6/6/88 | 290 | 5860 | 12 | 2600 | 10 |
| 21 TLDD HACIENDA | A4 NE CORNER | 6/7/89 | 560 | 6665 | 11.8 | 3000 | 20 |
| 21 TLDD HACIENDA | A4 NW CORNER | 6/7/89 | 620 | 6690 | 11.2 | 3000 | 21 |
| 21 TLDD HACIENDA | C1 | 6/6/88 | 130 | 1090 | 21 | 460 | 68 |
| 21 TLDD HACIENDA | C1 NW CORNER | 6/7/89 | 62 | 960 | 14.4 | 230 | 14 |
| 21 TLDD HACIENDA | C1 SE CORNER | 6/7/89 | 65 | 985 | 14 | 210 | 17 |
| 21 TLDD HACIENDA | C2 | 6/6/88 | 280 | 1640 | 19 | 750 | 36 |
| 21 TLDD HACIENDA | C2 (a) | 6/7/89 | 220 | 1520 | 16.6 | 590 | 23 |
| 21 TLDD HACIENDA | C2 (b) | 6/7/89 | 215 | 1490 | 15.3 | 570 | 27 |
| 21 TLDD HACIENDA | C3 | 6/6/88 | 380 | 2070 | 18 | 950 | 20 |
| 21 TLDD HACIENDA | C3 | 6/7/89 | 360 | 2215 | 16.2 | 1100 | 22 |
| 21 TLDD HACIENDA | C4 | 6/6/88 | 405 | 3180 | 15 | 1800 | 21 |
| 21 TLDD HACIENDA | C4 | 6/7/89 | 750 | 5115 | 11.4 | 3000 | 17 |
| 21 TLDD HACIENDA | MARSH N CELL | 6/6/88 | 11 | 3340 | 36 | 1800 | 44 |
| 21 TLDD HACIENDA | MARSH N. CELL | 6/7/89 | 29 | 2365 | 15 | 460 | 13 |
| 21 TLDD HACIENDA | MARSH S CELL | 6/6/88 | <30 | 4535 | 41 | 2500 | 47 |
| 21 TLDD HACIENDA | MARSH S. CELL | 6/7/89 | 48 | 2480 | 14.9 | 610 | 11 |
| 22 TLDD, SOUTH | 1 N SIDE | 6/7/88 | 100 | 1170 | 17 | 390 | 42 |
| 22 TLDD, SOUTH | 1 SW SIDE | 6/7/88 | 100 | 1045 | 16 | 370 | 53 |
| 22 TLDD, SOUTH | 1 SW SIDE | 6/6/89 | 130 | 985 | 17 | 570 | 66 |
| 22 TLDD, SOUTH | 2 | 6/7/88 | 6 | 1270 | 15 | 370 | 17 |
| 22 TLDD, SOUTH | 2 | 6/6/89 | 120 | 1065 | 15.8 | 270 | 27 |
| 22 TLDD, SOUTH | 3 | 6/7/88 | 150 | 1545 | 15 | 460 | 10 |
| 22 TLDD, SOUTH | 3 | 6/6/89 | 100 | 1230 | 16.5 | 340 | 19 |
| 22 TLDD, SOUTH | 4 | 6/7/88 | 180 | 1900 | 15 | 600 | 10 |
| 22 TLDD, SOUTH | 4 NW CORNER | 6/6/89 | 160 | 1505 | 14 | 400 | 14 |
| 22 TLDD, SOUTH | 4 SE CORNER | 6/6/89 | 160 | 1480 | 17.2 | 380 | 21 |
| 22 TLDD, SOUTH | 5 | 6/7/88 | 225 | 2635 | 17 | 910 | 11 |
| 22 TLDD, SOUTH | 5 | 6/6/89 | 170 | 1615 | 13.5 | 410 | 11 |
| 22 TLDD, SOUTH | 6 | 6/7/88 | 370 | 3120 | 15 | 1300 | 11 |
| 22 TLDD, SOUTH | 6 | 6/6/89 | 220 | 1725 | 11.6 | 510 | 12 |
| 22 TLDD, SOUTH | 7 | 6/7/88 | 230 | 2210 | 10 | 910 | 17 |
| 22 TLDD, SOUTH | 7 | 6/6/89 | 280 | 1998 | 10.6 | 670 | 13 |
| 22 TLDD, SOUTH | 8 | 6/7/88 | 240 | 2250 | 8.7 | 860 | 13 |
| 22 TLDD, SOUTH | 8 | 6/6/89 | 340 | 2762 | 11.4 | 1000 | 17 |
| 22 TLDD, SOUTH | 9 | 6/7/88 | 290 | 3350 | 9.7 | 1400 | 7 |
| 22 TLDD, SOUTH | 9 | 6/6/89 | 520 | 4010 | 10.2 | 1500 | 11 |
| 22 TLDD, SOUTH | 10 | 6/7/88 | 500 | * 7600 | 9.8 | 3100 | 14 |
| 22 TLDD, SOUTH | 10 | 6/6/89 | 710 | 8310 | 14.6 | 3200 | 17 |
| 22 TLDD, SOUTH | INLET | 6/7/88 | 120 | 1065 | 30 | 460 | 85 |
| 22 TLDD, SOUTH | INLET | 6/6/89 | 98 | 938 | 21.4 | 500 | 65 |
| 22 TLDD, SOUTH | PERIM DRAIN | 6/7/88 | 79 | 2100 | 3.4 | 400 | 50 |
| 22 TLDD, SOUTH | SALT BASIN | 6/7/88 | 230 | 1670 | 20 | 630 | 25 |
| 22 TLDD, SOUTH | SALT BASIN | 6/6/89 | 230 | 1590 | 18.4 | 520 | 45 |

APPENDIX B. Trace Element Water Quality Data

| SITE NAME | CELL | DATE | As | Mo | Se | U | V |
|---|---|---|---|---|---|---|---|
| | | | (ug/L) | | | | |
| 23 LOST HILLS WD | 1 (a) | 6/7/88 | <20 | 1565 | 176 | 180 | 35 |
| 23 LOST HILLS WD | 1 (a) | 6/7/89 | 10 | 1130 | 149 | 110 | 39 |
| 23 LOST HILLS WD | 1 (c) | 6/7/88 | <20 | 1355 | 177 | 200 | 40 |
| 23 LOST HILLS WD | 1 (c) | 6/7/89 | 23 | 434 | 157 | 210 | 70 |
| 23 LOST HILLS WD | 1-INLET | 6/7/88 | <10 | 796 | 142 | 120 | 24 |
| 23 LOST HILLS WD | 1-INLET | 6/7/89 | 4 | 745 | 150 | 150 | 22 |
| 23 LOST HILLS WD | 2 EAST | 6/7/89 | 31 | 2505 | 326 | 335 | 112 |
| 23 LOST HILLS WD | 2 WEST | 6/7/89 | 35 | 2365 | 334 | 330 | 112 |
| 23 LOST HILLS WD | 3A NORTH | 6/6/88 | <50 | 3480 | 598 | 480 | 73 |
| 23 LOST HILLS WD | 3A NORTH | 6/7/89 | 28 | 2635 | 492 | 370 | 54 |
| 23 LOST HILLS WD | 3A SOUTH | 6/6/88 | <50 | 3440 | 603 | 480 | 68 |
| 23 LOST HILLS WD | 3A SOUTH | 6/7/89 | 39 | 2350 | 539 | 360 | 75 |
| 23 LOST HILLS WD | 3A-INLET | 6/7/89 | 3 | 1207 | 671 | 110 | 20 |
| 23 LOST HILLS WD | 3B NORTH | 6/7/88 | 42 | 2020 | 156 | 340 | 42 |
| 23 LOST HILLS WD | 3B-NORTH | 6/7/89 | ND | 1923 | 275 | 370 | 34 |
| 23 LOST HILLS WD | 3B SOUTH | 6/6/88 | <30 | 1605 | 135 | 310 | 33 |
| 23 LOST HILLS WD | 3B-SOUTH | 6/7/89 | ND | 1445 | 244 | 330 | 50 |
| 23 LOST HILLS WD | 3B-INLET | 6/7/89 | ND | 1111 | 82.7 | 280 | 19 |
| 23 LOST HILLS WD | 3C | 6/6/88 | <30 | 1450 | 126 | 240 | 40 |
| 23 LOST HILLS WD | 3C | 6/7/89 | 27 | 3395 | 225 | 530 | 35 |
| 23 LOST HILLS WD | 4-NE | 6/6/88 | <40 | 2270 | 163 | 340 | 49 |
| 23 LOST HILLS WD | 4 NE | 6/7/89 | 59 | 5355 | 296 | 740 | 63 |
| 23 LOST HILLS WD | 4-NW | 6/6/88 | <40 | 2150 | 161 | 350 | 50 |
| 23 LOST HILLS WD | 4-NW | 6/7/89 | 56 | 5383 | 276 | 790 | 64 |
| 23 LOST HILLS WD | B. PIT | 6/7/88 | 30 | 1170 | 102 | 200 | 34 |
| 23 LOST HILLS WD | BORROW PIT | 6/7/89 | 33 | 464 | 29.4 | 150 | 15 |
| 24 CARMEL RANCH | 1 | 6/6/88 | 1100 | 5430 | 2.1 | 1100 | 240 |
| 24 CARMEL RANCH | 1 | 6/7/89 | 1200 | 3900 | 1.4 | 760 | 259 |
| 24 CARMEL RANCH | 1-INLET | 6/7/89 | 560 | 1285 | 0.8 | 290 | 285 |
| 24 CARMEL RANCH | 2 | 6/6/88 | 3950 | 22850 | 4.6 | 10000 | 216 |
| 24 CARMEL RANCH | 2 | 6/7/89 | 14000 | 44100 | 5.64 | 22300 | 150 |
| 24 CARMEL RANCH | 3 | 6/6/88 | 1800 | 9550 | 3.9 | 4000 | 87 |
| 24 CARMEL RANCH | 3 | 6/7/89 | 820 | 5030 | 4.07 | 850 | 35 |
| 24 CARMEL RANCH | 4 | 6/6/88 | 330 | 2425 | 4.1 | 770 | 104 |
| 24 CARMEL RANCH | 4 | 6/7/89 | 410 | 3215 | 3.94 | 870 | 79 |
| 24 CARMEL RANCH | 4A-INLET | 6/7/89 | 360 | 2325 | 4.58 | 820 | 143 |
| 24 CARMEL RANCH | 5 | 6/6/88 | 3700 | 10450 | 3.1 | 2500 | 489 |
| 25 LOST HILLS RANCH | 1 | 6/6/88 | 660 | 2815 | 2.8 | 200 | 223 |
| 25 LOST HILLS RANCH | 1 | 6/7/89 | 800 | 2510 | 1.94 | 190 | 212 |
| 25 LOST HILLS RANCH | 1-INLET | 6/6/88 | 560 | 2760 | 2.4 | 200 | 228 |
| 25 LOST HILLS RANCH | 1-INLET | 6/7/89 | 320 | 2095 | 2.12 | 160 | 246 |
| 25 LOST HILLS RANCH | 2 | 6/6/88 | 1200 | 4805 | 3.8 | 360 | 216 |
| 25 LOST HILLS RANCH | 2 | 6/7/89 | 1300 | 3880 | 2.49 | 300 | 147 |
| 25 LOST HILLS RANCH | 3 | 6/7/89 | 2400 | 7080 | 4.7 | 590 | 272 |
| 26 SAM ANDREWS' SONS | 1 | 6/6/88 | <20 | 1825 | 239 | 340 | 6 |
| 26 SAM ANDREWS' SONS | 1 | 6/7/89 | 6 | 2690 | 196 | 420 | 8 |
| 26 SAM ANDREWS' SONS | 2A | 6/6/88 | <20 | 2220 | 286 | 430 | 12 |
| 26 SAM ANDREWS' SONS | 2A | 6/7/89 | 9 | 5510 | 130 | 810 | 10 |
| 26 SAM ANDREWS' SONS | 2B | 6/6/88 | <20 | 2005 | 257 | 380 | 7 |
| 26 SAM ANDREWS' SONS | 2B | 6/7/89 | 7 | 4260 | 166 | 630 | 9 |
| 26 SAM ANDREWS' SONS | 3A | 6/6/88 | <20 | 2560 | 339 | 510 | 17 |
| 26 SAM ANDREWS' SONS | 3A | 6/7/89 | ND | 4425 | 334 | 790 | 7 |
| 26 SAM ANDREWS' SONS | 3B | 6/6/88 | <20 | 2380 | 307 | 460 | 16 |
| 26 SAM ANDREWS' SONS | 3B | 6/7/89 | 16 | 6875 | 570 | 1200 | 16 |
| 26 SAM ANDREWS' SONS | 4A | 6/6/88 | <30 | 3960 | 456 | 780 | 26 |
| 26 SAM ANDREWS' SONS | 4A | 6/7/89 | 21 | 9275 | 960 | 1500 | 37 |
| 26 SAM ANDREWS' SONS | 4B | 6/6/88 | <50 | 12300 | 1193 | 2200 | 42 |
| 26 SAM ANDREWS' SONS | 4B | 6/7/89 | 27 | 12100 | 1019 | 1800 | 37 |
| 26 SAM ANDREWS' SONS | SUMPS | 6/7/89 | 6 | 1685 | 212 | 280 | 5 |

ND = No Data